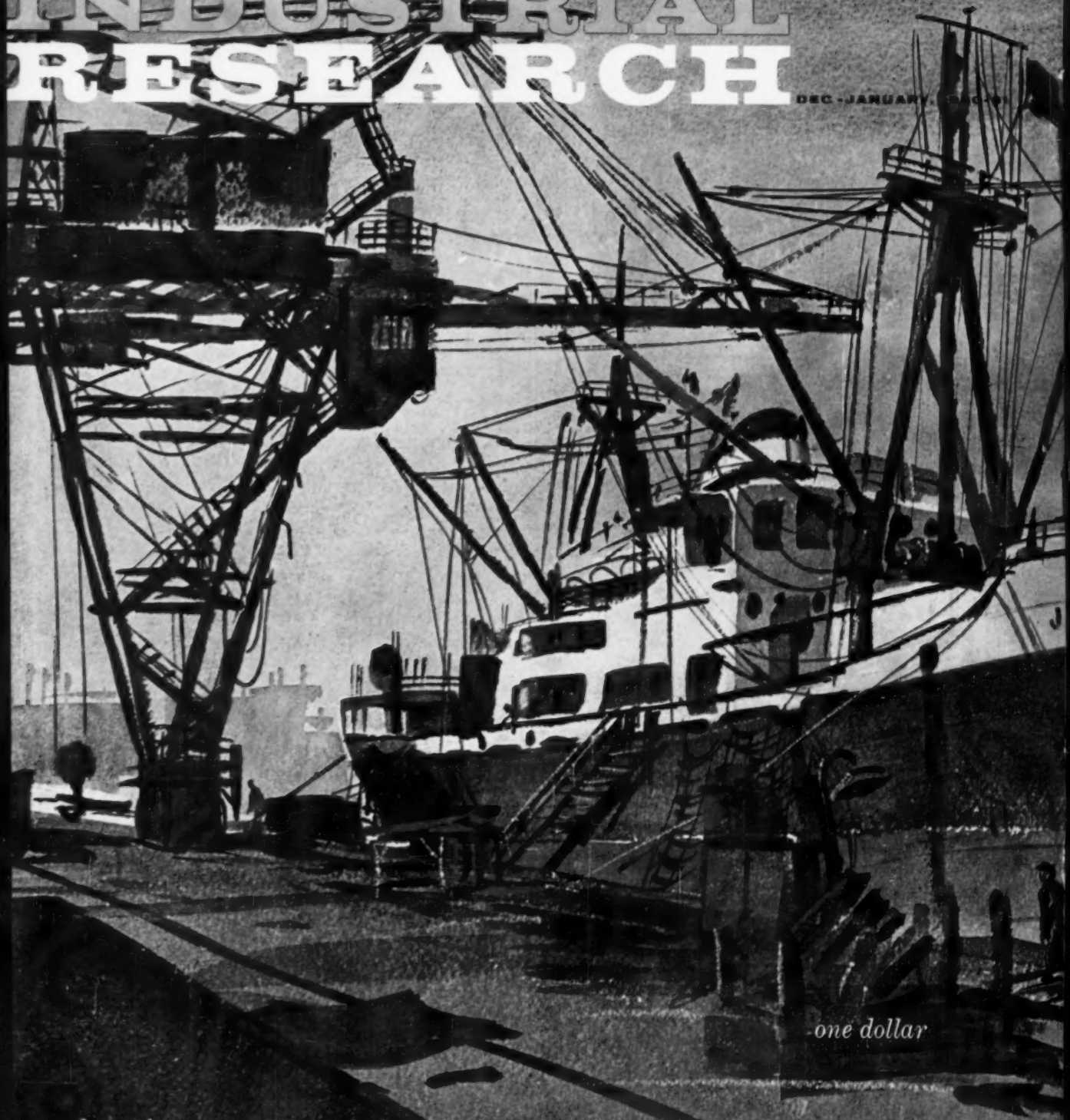
INDUSTRIAL RESEARCH

DEC.-JANUARY, 1960-61



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THE COVER, *a watercolor painted for I·R by artist Felix Palm, shows the French freighter* Joliet *being unloaded at Chicago's Calumet Harbor. The harbor, an extension of the Atlantic Ocean made possible by the St. Lawrence Seaway project, illustrates the emergence of a growing foreign competition, subject of the special section in this issue.*

While on the one hand the research, development, production, and marketing foreign-aid programs of the United States have bolstered war-torn or underdeveloped economies, they have served on the other hand to provide the U.S. with new competition. In the long run this may be for the good, since foreign markets cannot exist without higher standards of foreign living, and the attendant industrial competition is a natural result of these higher standards.

The four articles in this section — Europe's New Industry: Threat or Promise?, The Contest in Steel, World Rise in Plastics, *and* Computer Progress in Japan *attempt to penetrate this seeming paradox and shed some light on specific research and industrial developments.*

This issue also attempts to steer a way through the murky claims of computer devotees with two articles on computer applications — Computer Applications in Industrial Research *and* Computer Applications in Chemical Processing.

Several years ago, a new chemical, gibberellic acid, was announced as the wonder-drug of agriculture. The Stunted Growth of Gibberellin *is an account of technical and commercial progress to date with this "Jack-and-the-beanstalk" chemical.*

Lastly, the Speedup in Office Copying *is told in a hopefully unbiased manner to create a pattern out of the many new and wonderful copying-machine developments now emerging from research laboratories.*

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DEC-JAN 1960-61

INDUSTRIAL RESEARCH

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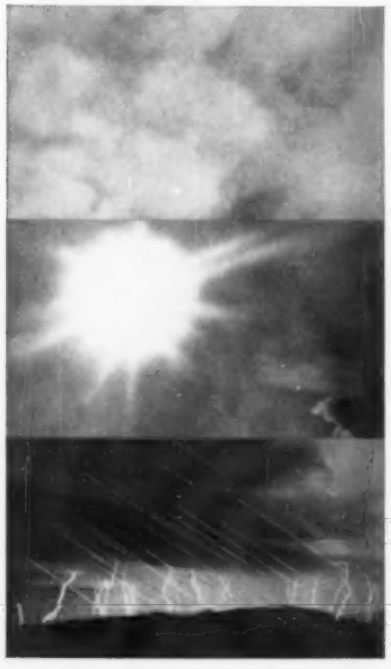

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IR FEEDBACK *from readers*

One reader's survey

Sir:

I just came across the results of your survey about "What Motivates the Technical Man?" in the June-July issue, and thought it was very enlightening. You have done an unusually fine job of describing the relationships of engineers and scientists to the companies that employ them.

Several months ago I decided to look for a new position, and ended up conducting a "survey" of my own that I thought other readers would like to know about.

The first thing I did was to read the employment ads in your magazine and others, and also in two major newspapers that carry Sunday recruitment advertising.

Because I am a senior electronics engineer, the prospects looked encouraging. I had an excellent academic record in a good university, two degrees, several years of worthwhile experience, and several patents to my credit. In other respects, I have no major handicaps. I am not identified with national or racial groups, which are the last to be hired, nor do I have trouble getting along with people.

From the recruitment advertising I studied, it seemed that about all I would have to do was pick the place I would like to work, excluding as possibilities those companies needing very highly specialized men. So to get a concrete idea of opportunities that might be open, I prepared a resume and sent a copy along with a letter to about 25 well-known companies in different parts of the country, and to a few employment agencies that advertised a specific position.

The results were astonishing.

While I hardly expected to get 25 job offers by return mail, the fact is that *more than half of the companies failed to reply at all*, even though I'd addressed each letter as instructed by the advertisement.

I had two phone calls within a few days, one leading to my acceptance of a position. Other answers started coming in a week after I mailed my letters, and continued for about six weeks.

Some contained an application form. (One major aircraft company has a long form that expressly requires giving the *middle name, not just the middle initial*, of all persons used as references. Another major aircraft company makes a far better impression by requesting only information about past employment that might not be included in a separate resumé.)

Two companies invited me to visit them at their expense, and did not request that an application be filled out. A few companies replied with a personal letter explaining they did not have a current suitable opening. I called the personnel department of one large respected company in the city I was located to discuss advertised openings. The personnel manager said he would send an application form, but it never arrived.

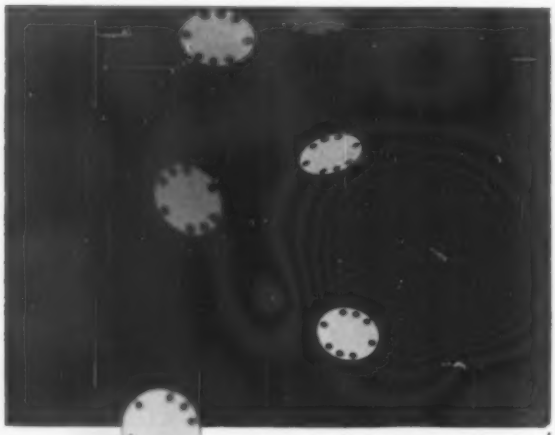
Answers from agencies, which had been so specific about positions in the ads, were now very vague, not only about the type of company but about the type of job as well. Agencies mainly were interested in securing my signature on a contract.

This experience convinced me that the well-recognized (by engineers) poor quality of personnel departments is destroying companies' million-dollar advertising programs.

Companies that handle recruitment inquiries quickly and efficiently have a major competitive advantage in solving their engineering shortage, if they have one. When an engineer decides to change positions, he is not going to be available indefinitely, usually not for even a month.

Lethargic "personnel personnel" who neglect answering a respectable inquiry are negating the corporate dignity that many companies are trying to build. Such firms not only waste advertising funds, but ignore potentially valuable employes or future well-disposed customers.

(Name withheld by request)



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Sounds on sound

Sir:

Concerning your special section on sound, you may be interested in knowing that we have conducted tests in the field of sound, and have noticed some direct correlation between sound and vibration testing such as experienced in the environmental test requirements by various defense agencies.

Yours is an excellent publication, and I am sure that you will continue experiencing success.

Emile J. Petre
General Manager
Stephens Trusonic Inc.
Culver City, Calif.

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Sir:

The article "Life Sounds and Communications" is well-written, factual, and contains a reasonable hypothesis for things to happen in the future.

Dr. Robert W. Benson
Prof. of Electrical Engineering
Vanderbilt Univ.
Nashville, Tenn.

Reliability

Sir:

The articles on reliability in your Oct-Nov issue were quite interesting. They provide one example of the increasing interest of the engineering profession toward producing highly reliable equipment.

A program currently underway is the development of an ultra-reliable receiver in the frequency range from 1700 to 2300 megacycles. A preliminary model has been delivered to WADD which has a predicted "mean time between failures" of 38,000 hours. Another model being life-tested by the contractor has operated so far for more than 4,000 hours without a failure.

We feel that reliability techniques utilized in this program are valuable for use in all types of communications equipment development. Emphasis is on design and circuitry techniques, rather than quality control.

In the future it appears that the design engineer will become more and more a reliability engineer. Reliability must be introduced in the earliest stages of development and carried through operational life.

George H. Scheer
Chief, Basic Techniques Branch
Communications Laboratory
Wright Air Development Division
Wright-Patterson A. F. Base, O.

Sir:

Your two excellent articles on reliability were called to my attention. More articles on the engineering problems of reliability such as the one by Mr. Tall are needed in the engineering field.

R. H. Gauger
Hazeltine Electronics Div.
Little Neck, N.Y.

Miniaturization

Sir:

I was greatly impressed by the article on miniaturization (Aug-Sept issue), and thought the treatment of the subject was excellent. I gather from talking with some of my associates that this article has attracted favorable interest among engineers and designers with whom we are in contact.

H. D. Gilbert
President
Miniature Precision Bearings Inc.
Keene, N.H.

Technical motivation

Your interest in "Motivating the Technical Mind" (Vol. 2, No. 2) prompts me to write concerning the problem of motivating the technical student. The number of talented students who do not finish their technical education is alarming.

Perhaps even more important, a large share of students who do get their engineering degree have not achieved the level of technical excellence they should have.

Now I appreciate there are many factors that have something to do with this problem. However I have a deep conviction that motivation is one of the important variables involved. It also seems to me that motivation is an issue receiving the least attention, at least in our college.

We study curricula arrangements in great detail, select the student with care, counsel students extensively, urge instructors to perfect themselves technically, and so on, but the results of all this seem to be far less effective than one would expect.

I suspect the major reason we neglect a serious and orderly study of motivation is that we just do not understand the basic principles involved. Suggestions from readers would be appreciated.

K. E. Smith
Chairman
Aeronautical Engr. Dept.
Univ. of Detroit
Detroit 21, Mich.

Planning research

Sir:

Planning research is a tough business all around. I have concluded that it is just as well not to plan at all, because the plans never work out anyway. In my company we have a semiannual ritual—a budget period—when we plan costs, personnel requirements, and space needed. Then we proceed to allocate our resources to a number of worthwhile endeavors and also to pet projects of the company management that we don't intend to work on anyway.

But if you have to make plans, you make them, and the job seems easier if you get it done as fast as possible, which means recognizing how futile it is to attempt predictions and simply write down num-

bers that will get management off your back. After the ceremony is over, peace is restored for another six months, and we can go on with the work that should be done.

(Name withheld by request)

Instrumentation & control

Sir:

Your June-July issue on instrumentation and control was most excellent. This publication appeals to me particularly well.

Charles F. Charters
Control Systems Engineer
Wyandotte Chemicals Corp.
Wyandotte, Mich.

copyright 1960, The New Yorker Magazine, Inc.

Penetrating rays

I've finally caught up with the Feb-Mar issue and Ted Berland's excellent article on "The Industrial Uses of Penetrating Rays."

S. A. Wenk
Manager, Accelerator Applications
Radiation Div.
Varian Associates
Palo Alto, Calif.

General feedback

Sir:

I have examined all the issues of Industrial Research with considerable care and hasten to commend you on a very fine job—quite the finest of its kind I have ever seen.

I presume you are bombarded with a considerable offering of contributed material of a "sales-promotion" type. I can appreciate the temptations to open the flood gates to this type of literature, but I will have done my part if I can encourage you to resist these temptations.

Frankly, your efforts on the higher-level types of articles have been *so* good that I feel you can make yourselves a comfortable niche in this field. The sales type of article is dime a dozen and usually only provides fodder for the incinerator.

The difference in impact and reader interest between your type of articles and the sales type is evident. It seems to me that you are creating in your field what *Fortune* is doing in its field and perhaps going them one better.

John A. Hannum
Washington, Mich.

Sir:

You are doing a fine job both in physical layout and in the contents of your articles.

Howard K. Janis
Manager
Research & Engineering Info.
IBM Corp.

Sir:

I find the articles in *Industrial Research* very interesting, timely, and closely allied to activities within my division.

Charles A. Zelaites
Director
Engineering Design Div.
U.S. Army Signal R&D Laboratory

Sir:

I enjoy your magazine very much and think it's one of the finest published.

Larry Smith
Minneola, Kan.

Sir:

Thank you for the publication of my short note in your last issue. I have received several interesting comments from your readers and am enclosing one of them from L. E. O'Rourke, pilot plant branch head, Physical Sciences Laboratory, Melpar Inc., and recommend that you publish it in your "Feedback" column:

"Dear Mr. Borgen: I have long felt as you do with regard to the commercial development of military-sponsored research. In my opinion the consumer public is entitled to derive maximum benefits from the byproducts of military research, both in terms of new and better products and in new employment opportunities. Industry is entitled to develop, produce, and sell new materials and products based on tax-supported research.

"However, I feel that thus far there has been very little commercial exploitation of the wealth of scientific and engineering information produced by government-supported R&D.

"There are two reasons. First the R&D engineer and his organization are not attuned to, or concerned with, commercial development. Second, entrepreneurs and business people become quickly lost in the maze of research information. They have difficulty in recognizing saleable products in the reports of research work.

"What appears most serious is that these two groups may not even be aware of the need for an exchange of communication. A constant flow of new intelligible information to the people in a position to exploit the products of the future is necessary."

Hal Borgen
Lumen Inc.

Sir:

I enjoy your publication and read it regularly. It is a handy reference in my job as a research engineer at the NASA.

George R. Smolak
Lewis Research Center

COMPUTERS 1:

applications in industrial research

by **Maurice W. Horrell,**
general manager,
Bendix Computer Division

Maurice Horrell joined The Bendix Corp. in 1948, served as supervisory engineer and executive engineer of the research laboratories in Detroit, then came to the Computer Division shortly after it was formed in 1952. He was named general manager in 1954. Horrell holds an MS in electrical engineering from Kansas State University, and is co-author of the textbook Basic Electronics *(John Wiley & Sons, 1949).*

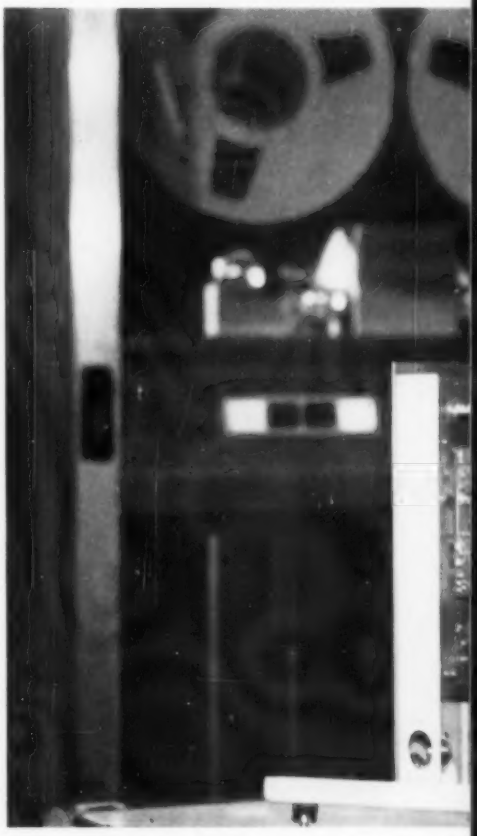
COMPUTERS, both analog and digital, have been pictured as falling into several competitive camps: military versus industrial, business versus research, general-purpose versus special-purpose types.

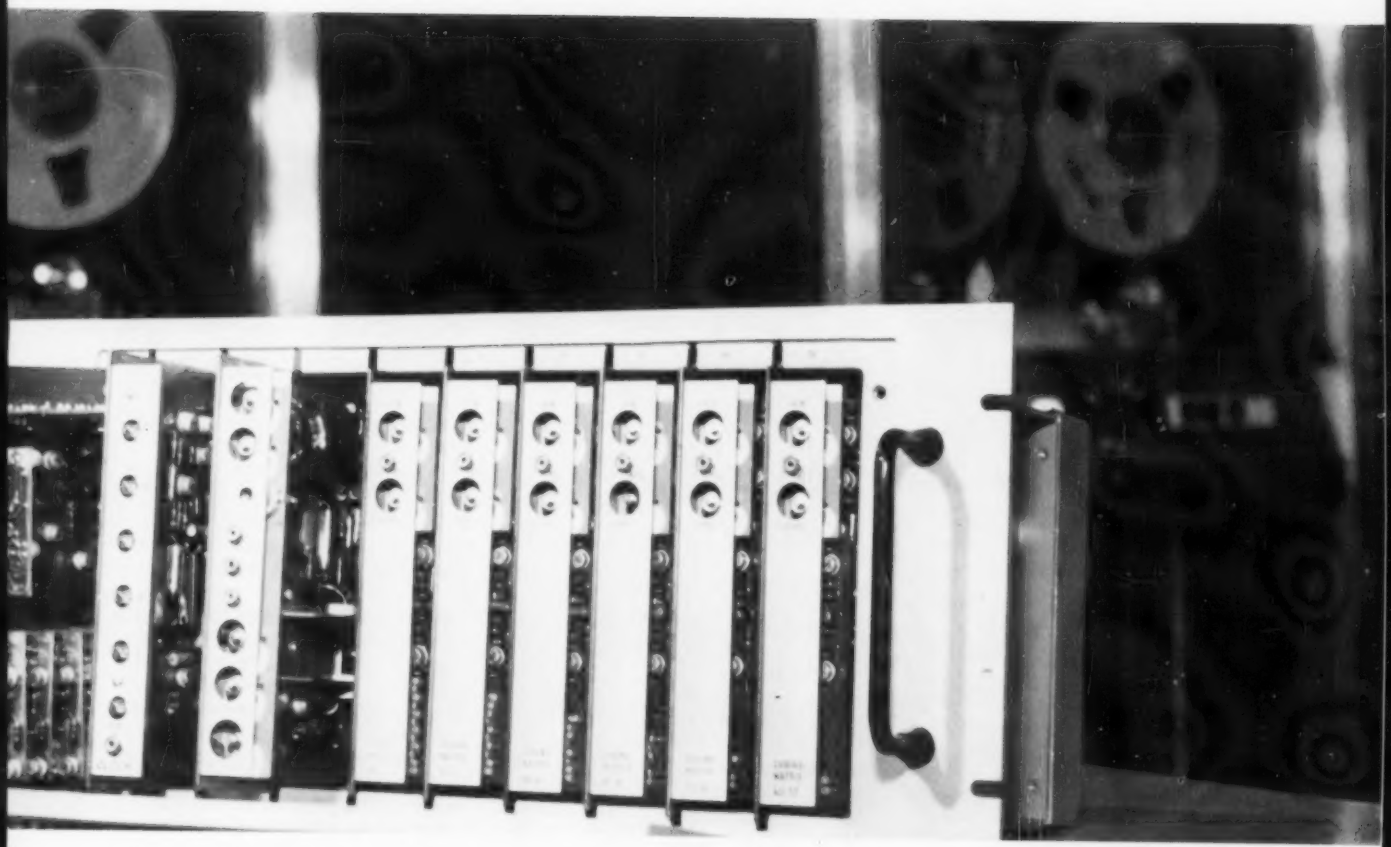
■ It is true that the most advanced computers today are being designed for military requirements where dollars are not all important. For instance, compactness, ability to withstand temperature extremes, and high reliability are of more importance than cost in computers for missile guidance. On the other hand, manufacturers of computers feel that commercial users are more interested in how much computing they can get done per dollar invested. Thus competition, as such, does not exist between military and industrial computers; rather, technical know-how gained in developing each class has helped the other.

■ Some have felt that the distinction between business-type and research computers is decreasing. Business computers are fast on input and output of data, but slow on calculations; research computers vice-versa. An increasing awareness now exists among computer manufacturers that many companies want computers for both data processing and scientific usage (for example, all scientific users have payrolls to compute). However, as both research and business applications grow more sophisticated, both data-processing computers and scientific computers are expanding and overlapping their markets.

■ Little competition actually exists between general-purpose and special-purpose computers. Both are being built at increasing rates.

This article will show where general-purpose computers in the small-to-medium-size range are being used, and how major benefits can be derived. Computer installations for research fall into two categories of use. In some installations a computer works in conjunction with other data-processing equipment. In others, a computer serves the engineer as a problem-solving mathematical tool. *(continued, page 16)*





ANALOG-TO-DIGITAL CONVERTER *(above), by Raytheon, measures less than a cubic foot, performs 2.5-million conversions per second. About 50 times faster than anything similar on market, it converts an analog, or continuously variable, signal into a number for processing by more-versatile digital computer. High accuracy—0.5% of full scale—is claimed. At right, research into automated teaching devices is being conducted at System Development Corp. Experimental system consists of a computer as the control and memory element, a typewriter keyboard through which the student and computer communicate, and a random-access slide projector controlled by the machine that displays questions for the student.*

Data-processing applications

Many examples exist of general-purpose digital computers acting as an essential part of a test-data gathering or processing system. For example, in textile-fiber research, measurements of thread tests are processed by a computer to yield such information as strength, durability, resilience, elongation, etc.

Data from stress-analysis measurements of the thread—including tensile strength, extension, and stress on the fiber during stretching tests—are recorded automatically on tape. The computer takes this information and calculates the yield and breaking points of the thread. Tests are run on samples of 20 to 25 threads, then data from the samples are averaged statistically. The averages are more consistent and trustworthy, and test results are available almost immediately.

Formerly it was necessary to read the information from a graph and then manually calculate the averages. The computer eliminates tedious computation and the necessity for relying on less-accurate graphical presentations. If desired, the tape-recording step can be eliminated, or carried on simultaneously with the processing of test data.

Submarine or whale?

Cataloging underwater sounds is an interesting application of a general-purpose computer. Severe masking of underwater sounds is caused by natural conditions of continual noise. Distortion of sound patterns can be created by such things as a passing school of fish, bubbles, waves, or the motor of a nearby boat.

The goal is to detect and classify different objects in spite of similarities, and efforts to identify the source of a distortion have been only partially successful. The problem is so severe that whales have been mistaken for submarines.

Shipboard recordings are made by the sound division of the Naval Research Laboratory and then brought back to the lab for study. A computer is invaluable for processing data that must be analyzed in order to pinpoint differences in sound.

At General Electric's lamp division a computer is tied into special equipment designed to measure properties of different light sources. The computer serves as an integral part of the data-measuring process, making computed results available immediately, when results are often of greater value.

In installations where computers are part of a system, it has been found that as much as 80% of the computer time may be devoted to processing of test data. Remaining machine time in the typical installation is used for one-shot problems, answering questions that may not come up again.

Problem-solving applications

In contrast to those installations where a computer earns its keep as part of a testing or data-handling system are applications where the computer becomes a problem-solving tool for a technical staff.

More than 15% of all Bendix G-15 installations, for instance, are found in the petroleum and chemical industries. Petroleum industry computer users have developed mathematical models to simulate an oil reservoir.

Numerical solutions to these models are used in the study of pressure buildups and reservoir flow as an aid in determining the most efficient methods of recovering oil. Such simulation techniques can be very complex and may require hundreds of hours of computing time. This processing sometimes is done at night so that the computer can be used for other problems during the day.

Under certain conditions more oil can be recovered from a reservoir if the technique of water-flooding is used. To arrive at an injection well pattern that will result in the most economical recovery, data at as many as 300,000 locations may have to be analyzed. A change in pressure at one point affects the pressure at every other point. Physical conditions also must be considered such as porosity of the oil-bearing rock, permeability, hydrostatic pressure, gravity, and capillary forces.

Before computers became available, the petroleum industry had to base improvements in recovering oil from a reservoir only upon past experience—experience that frequently took years to acquire. Mathematical simulation methods make it possible to obtain the equivalent of years of experience in hours, in a controlled laboratory situation and without loss in production.

Oil reservoir calculations demonstrate how computers have made practical the use of mathematical techniques which, though well known previously, could not be applied effectively. The time required for hand calculation had proven prohibitive (as in the classic Richardson proposal, in which a mathematician sought to harness 60,000 human calculators for meteorological work—see inset, page 18).

Programing gasoline blends

The petroleum industry also uses computers in gasoline-blending calculations. Linear-programing techniques are applied to find optimum blends. A number of variables affect optimum blending — raw - material supplies, weather, and marketing demands. These contribute to continually changing conditions which produce interrelated effects upon the different variables.

A program by Aurora Gasoline Co. permits analysis of as many as 37 restrictions and 37 variables, accounting for compositions of blends and their specifications, and the current marketing value for each by-product. Aurora can adjust blends more accurately to realize marketing needs, and can investigate the effects of blend changes without trial production runs.

The same program could be applied to diverse problems involving factory production and inventory control, regulating product mix for chicken or livestock feed, storage and distribution of goods, or allocating personnel.

Learning from past records

Multiple-regression techniques (for determining the degree of correlation of variables in a complex situation) are mechanized by computer programs in many research laboratories. At the B. F. Goodrich Chemical Co. Development Center, for instance, regression techniques analyze past production records of a complex process such as polymerization.

It is possible to separate the effects of many variables, and since great quantities of data can be handled, conclusions are based upon the averages of many runs, a procedure which increases statistical confidence. B. F. Goodrich engineers feel that the availability of this program makes data collecting really useful, and allows them to obtain the maximum benefits from experience.

The use of a computer to simulate a physical process is found widely, particularly in the chemical industry. Often a chemist can study an experimental "batch" on the computer faster and cheaper than he can set it up in the laboratory.

Sometimes, a computer program will be written to study an entire chemical processing plant. (See

Computer Applications in Chemical Processing, page 20.) The preparation of such a complex problem for mathematical analysis may reveal basic weaknesses in the system or process. In this case, major benefits may come from the system review required to accomplish the computer programing, rather than from computations performed.

A computer at the American Viscose R&D center was installed originally to introduce new techniques to the staff. As the scientists gained familiarity, increasingly advanced applications were found, such as predicting sales curves for a product, establishing statistical correlations of accidents that could lead to reduction of accidents, and investigating the effects of additives on established chemical products.

These computer methods not only save time in reducing existing data, but reveal more information than would come to light under ordinary laboratory or record-keeping conditions.

Choosing polymer characteristics

American Viscose chemists switch to computer usage when an experimental polymer begins to show promise. A mathematical model permits optimum selection of one or more polymer characteristics. A model may contain equations relating 12 physical characteristics, such as tensile strength, color and elongation, to 16 process variables, such as bath temperature, stretch, and size of die opening. A complete analysis can be made in two hours.

Polymers that show particularly strong potential are given an even more exacting analysis by deriving a set of partial differential equations relating the variables involved, setting all the derivatives to zero, and solving simultaneously to find optimum values.

The American Viscose staff has developed an infrared spectroscopic "spectrasearch" program for the identification of unknown compounds. Such spectrum identification once meant hand-searching records of as many as 10,000 known spectra. The search program makes use of magnetic tape units to store a file of known spectra. File information on spectra that exhibit a specified number of points in common with the unknown is found by the computer and printed out by the console typewriter.

Indexing systems have been set up for automatic filing and retrieval of many kinds of information. Such routines frequently produce a more complete, correct, and comprehensive file, because in adapting and indexing a file for computer operation, more critical and accurate indexing methods are developed. These methods also are being applied to patent searches, engineering drawings, technical report indexing, and similar jobs.

A new management willingness

Today there appears to be a willingness by management to provide a computer for the technical staff without requiring a detailed rationalization about how it is used. Some management men feel that a scientist may be inhibited by having to justify time spent on the computer.

It is difficult to pinpoint how much money a computer makes or saves in a research project. Its chief value in many cases lies in the fact that analyses are made which otherwise would be impossible; work is done that otherwise would lie undone; facts are revealed that otherwise would remain unknown. Sometimes research is channeled into completely different directions as a result. A man with an idea often can follow it through on a computer without being delayed by tedious, time-consuming, and often inadequate mathematical analyses.

Model testing, a time-honored but costly method in engineering, also can be computerized. At the John Deere Tractor Research & Engineering Center, for instance, a computer has taken over some of the investigation formerly done by physical model testing.

One problem of particular interest is predicting performance of a tractor. In order to design gear ratios most effectively, the potential performance of the tractor must be known. Initial data consists of soil composition, characteristics of the engine as observed in the laboratory, and characteristics of the tractor—tire size, weight, wheel base, etc. This information now is typed into the computer and the performance is calculated. The engineer then can change design parameters until optimum design has been reached.

Automated learning

Unusual work is being done by System Development Corp. in investigating automated teaching devices and learning processes. Here the mathematical ability of the computer is ignored. Its capability for providing an extensive memory, available upon command, and its ability to make decisions based upon previously analyzed situations, are the qualities employed.

SDC scientists believe computers can become a "tutorial" extension of the instructor, supplying each student with individual instruction.

Two programs are involved in the learning situation—the subject material and instructions the computer follows in teaching this material. The computer determines whether a student who has missed questions should be provided with the answer, or should be told to try again. The computer may provide a correct answer if the student misses, or express approval, or advise the student to proceed to another concept, or recommend additional remedial work.

In conventional teaching situations, students progress at a rate which the teacher feels matches requirements of the class average. Bright or informed students are slowed down; the student who needs more help barely passes. The computer system provides a direct relationship of each student to the material to be learned. The passive student must participate in the entire learning process, and the fast student is jumped from concept to concept in keeping with his ability.

In the SDC system, a computer controls a slide projector that displays a question and multiple-choice answers. The student types in his answers. The computer responds and selects the next slide.

At the conclusion of such a course, the computer evaluates the student's answers and his opinion of how well he has learned the subject material. Then it decides whether review may be necessary or whether the student has "passed."

The common library

Many diverse applications such as those discussed require similar programs, and programs for computers are being developed almost daily. To avoid unnecessary duplication of efforts, computer manufacturers and users have set up common program libraries.

These libraries are composed of programs contributed by a single user, a team of users, or by the manufacturer's in-house programing team. In general, the basic compilers, assemblers, translators, and diagnostic routines are contributed by a manufacturer's staff. Specific problem-solving programs are more likely to originate with the users.

A computer can be no better than

the programs that are put on it. Users recognize this, and they know the usefulness of their installation is strengthened as new and better programs are added to the repertory. To this end, they have organized and have set up bylaws determining such things as qualifications for membership, conditions under which programs are to be distributed, and the form in which programs should be submitted. They meet periodically at conferences attended by all members, and in between times for special-interest sessions.

It is not at all uncommon to see a group of representatives from highly competitive companies seated around a table working together to improve their operations. Such a meeting may be a cooperative effort to prepare a package of statistical programs, or a presentation by one user of a more efficient way to code information for magnetic tape.

Even where there are government security or industry proprietary considerations, mathematical "links" that will become part of major programs can be shared, as can improved techniques or innovations.

Computer manufacturers support the users' organization under terms which they specify. As an example of the effectiveness of these organizations, there are now approximately 700 programs in the G-15 library. They run the gamut of almost everything imaginable that can be done with a computer, and a few things unimaginable.

Analog computers for research

While it is true that an analog computer cannot take advantage of program libraries, it is uniquely important for research as a design tool. An analog computer makes it possible to study in intimate detail the features and parameters of a physical system being synthesized. Consider one major application of analog computers: evaluating the controls and aerodynamics of a missile. When such a prospective system is simulated by means of an analog computer, it is extremely easy to vary the major parameters affecting performance, to see almost immediately what the effect is on the system.

An engineer using an analog computer as a tool need not be diverted by delays or the need to analyze appreciable quantities of data. With an analog computer the process of trial and error is an acceptable and sensible design approach.

Analog computers also are design tools capable of being readily modified, even to the point of serving as part of a physical system. For ex-

A UNIQUE COMPUTER APPLICATION

(condensed from Readout, *a publication of Ampex Data Products Co.)*

GIVEN:

1. Some 525,000 cubic miles of gas surrounding the northern hemisphere.
2. The present temperature, pressure, moisture content, velocity, and direction of gas movement measured at 3,000 points.
3. The values of these variables yesterday.

FIND:

The temperature, pressure, velocity, and direction of the gas movement 24 hours from now.

METHOD:

There are two:

1. Apply educated guesswork, and determine the condition of the gas in 24 hours, or . . .
2. Apply complex mathematical equations to the conditions reported from each measuring station, make 300-million computations, and modify the results with data from adjacent stations.

The first method is prophesy. The second is "numerical weather prediction."

The first method has been in use for more than a century. It works — most of the time — but requires hours of computation and is subject to much human interpretation. Numerical weather prediction, in contrast, can be done in minutes, with a minimum of human intervention, and can produce forecasts of other related phenomena — forecasts which before were completely impractical.

It all started in 1922 when an Englishman named L. R. Richardson first conceived the idea of predicting weather numerically. Richardson was a first-rate mathematician but an impractical dreamer. He had data from weather stations, and developed the equations to make forecasts.

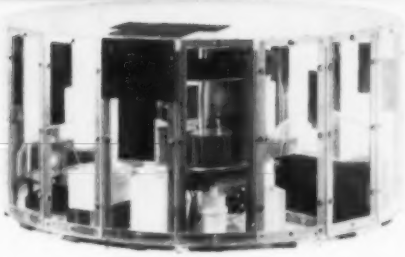
When he found it took three months with the aid of a desk calculator to produce the first 24-hour forecast (it was wrong), he came up with a human computer — 60,000 people stacked in a stadium. Since the data could be processed serially, one calculator would perform his operation, then pass the answer onto the next person for the next computation. Pageboys would transfer information from section to section.

Finally, a conductor would stand on a podium before this crowd and direct operations. When his baton went up it would mean to calculate; when it came down, the computer was to pass the results among itself.

For some reason, the stadium never was built.

Richardson had based his try on six non-linear partial differential equations known to meteorologists as the Primitive Equations. As Richardson learned, these equations cannot be applied to practical problems in their "primitive" form, but in 1939, C. G. Rossby in a classical simplification reduced the equations to a single one.

Then, in 1950, a group of mathematicians and meteorologists working



TIROS I *weather satellite, now orbiting, carries two TV cloud scanning cameras. Model shown is by Allied Research Assoc.*

at the Institute for Advanced Study at Princeton completed the last mathematical step which made it possible to apply Rossby's equation to the atmosphere.

The method of numerical weather forecasting that evolved is simple. Weather is associated with air movement and variations in atmospheric pressure over a given area. If you know what these variables were yesterday and what they are today, the application of the equations will tell you what they will be tomorrow. Precipitation and temperatures are the result of pressure conditions. If the computer can produce tomorrow's pressure conditions, then it is possible for a meteorologist to deduce the temperature and precipitation that will result.

The Navy Numerical Weather Problems Group (NANWEP), which will be established in Monterey, Calif. next month as a separate activity to provide forecasts to the fleet, has replaced Richardson's mass of humanity with a small digital computer and four tape transports. Weather reports reach NANWEP on six 100-word-per-minute teletype circuits.

There are 10,000 weather observation stations which could report, but delays in communications (and sometimes bad weather) prevent all the stations from reporting for each forecast. A good average is about 3,000.

Once the data have been processed, the second step is to make a map of existing weather. A grid of lines spaced 205 nautical miles apart is placed over the northern hemisphere. Each grid position is assigned an address. The weather reports from stations surrounding each position are used to interpolate a pressure value.

If there are not enough data from the area in the immediate vicinity of the position, then the computer scans outward from the point in ever-increasing circles until enough data are found. When all data have been analyzed, the computer can produce a pressure-pattern chart for existing weather in the northern hemisphere.

At this point the computer does not make an actual weather forecast, but predicts pressure changes at each grid position as a function of time. The application of mathematics like the Rossby equation produces the values that will exist in one hour. These values are used by the computer to predict what will happen at the end of two hours — and so on — until the desired forecast has been reached, usually 24 or 28 hours ahead.

NANWEP scientists feel that it will be a long time before we obtain enough measurements of existing weather to make absolute predictions of any future weather. Satellites will help; data from the TV satellite TIROS and other sources will provide a "third dimension" from which to view the overall weather situation. Although work is being done to enable TIROS to measure temperatures through infrared techniques, however, satellites can never provide enough medium- and low-altitude data.

The best we can do now is to refine the equations and programs with which numerical weather prediction is accomplished until we have exhausted the potential of available data. This, combined with a careful analysis of what went wrong with bad predictions, will produce better forecasts than are possible today.

Yet there still will be the element of chance, and 10 years from now the papers still may print ". . . with a possibility of rain in the afternoon."

(For additional information or for a copy of Readout *write to Ampex Data Products Co., Redwood City, Calif.)*

ample, during simulation of a physical system, portions of a computer can be replaced with actual components of the proposed systems, a process which contributes greatly to eliminating much of the unavoidable uncertainty concerning final performance of a complex system.

Major applications of analog computers for simulation occur when the physical system can be described by means of a differential equation. In addition to missile studies, naturals for analog studies are problems in vibration, transients in electric circuits, heat transfer, chemical reactions, and process control systems.

For example, one company has carried out extensive studies of vehicular suspension designs, investigating effects of mass distribution and location of reinforcing members on natural frequencies and overall stability.

Another company has carried on studies of oil-refining processes, in an effort to optimize performance. Heat-transfer studies exemplify problems involved in solving for values in a space continuum in two or three dimensions. In brief, an advantage of analog computers results from the ability to change a system without reprograming the computer.

On the other hand, when a design study requires the orderly repetition of many computations, analog computers usually are unsuitable to compute performance for all combinations of many different variables.

Analog-digital combinations

The combined use of analog and digital computers is found in some military installations and in chemical processing. Due to the high cost of equipment involved, it rarely is found in industrial laboratories. However, the problem-solving qualities of combined systems are becoming more widely practical.

The simulation laboratory at the Pacific Missile Range, Pt. Mugu, Calif., employes a combined analog-digital system hooked up to the flying controls of an aircraft. The system is used to check out displays by which a pilot aligns and fires on a target. Analog equipment simulates the plane's performance while digital equipment calculates his accuracy. The digital machine also provides radar input signals to the cockpit.

Whether analog or digital computers or combinations of the two are chosen for a particular application, they should not be thought of as mere work-savers, but as advanced tools to perform research and other tasks that often would be otherwise impractical. ■

COMPUTERS 2:

applications in chemical processing

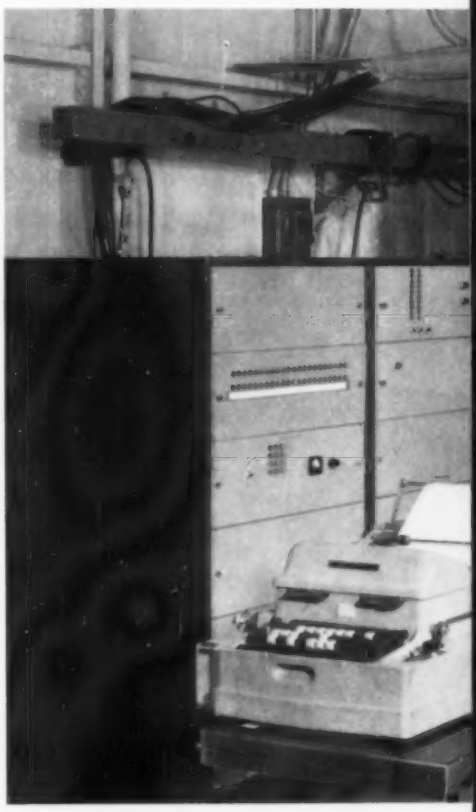
by **Alexis W. Lemmon Jr.,**
and **Benjamin B. Gordon,**
Battelle Memorial Institute

Alex Lemmon, assistant division chief, and Benjamin Gordon, project leader, are engaged in computer-applications research at Battelle Memorial Inst. Before joining Battelle, Lemmon was assistant professor of chemical engineering at Ohio State University, and prior to that served as consultant with A. D. Little Inc. and the Applied Physics Laboratory at Johns Hopkins. Gordon is engaged in instrumentation and systems engineering in Battelle's analog simulation laboratory.

USING COMPUTERS to provide complete automation of a chemical-processing operation is one of the most interesting concepts ever considered. Although computers and computer techniques have been used in many chemical and chemical engineering applications, adaptation to the complete control of a process or plant operation only recently has gone beyond the experimental stage.

The steps that must be taken to make various chemical processes automatic are well known. Chemists and chemical engineers have used computers successfully for many more or less limited tasks. The real problem is combining scattered pieces of know-how into integrated systems that can perform efficiently enough to be economically advantageous.

When automated chemical plants are achieved, the computer will be the "brain" to direct and watch over the processes, under human guidance. How such computers can be used and the areas in which they are likely to be useful will be considered in this article.

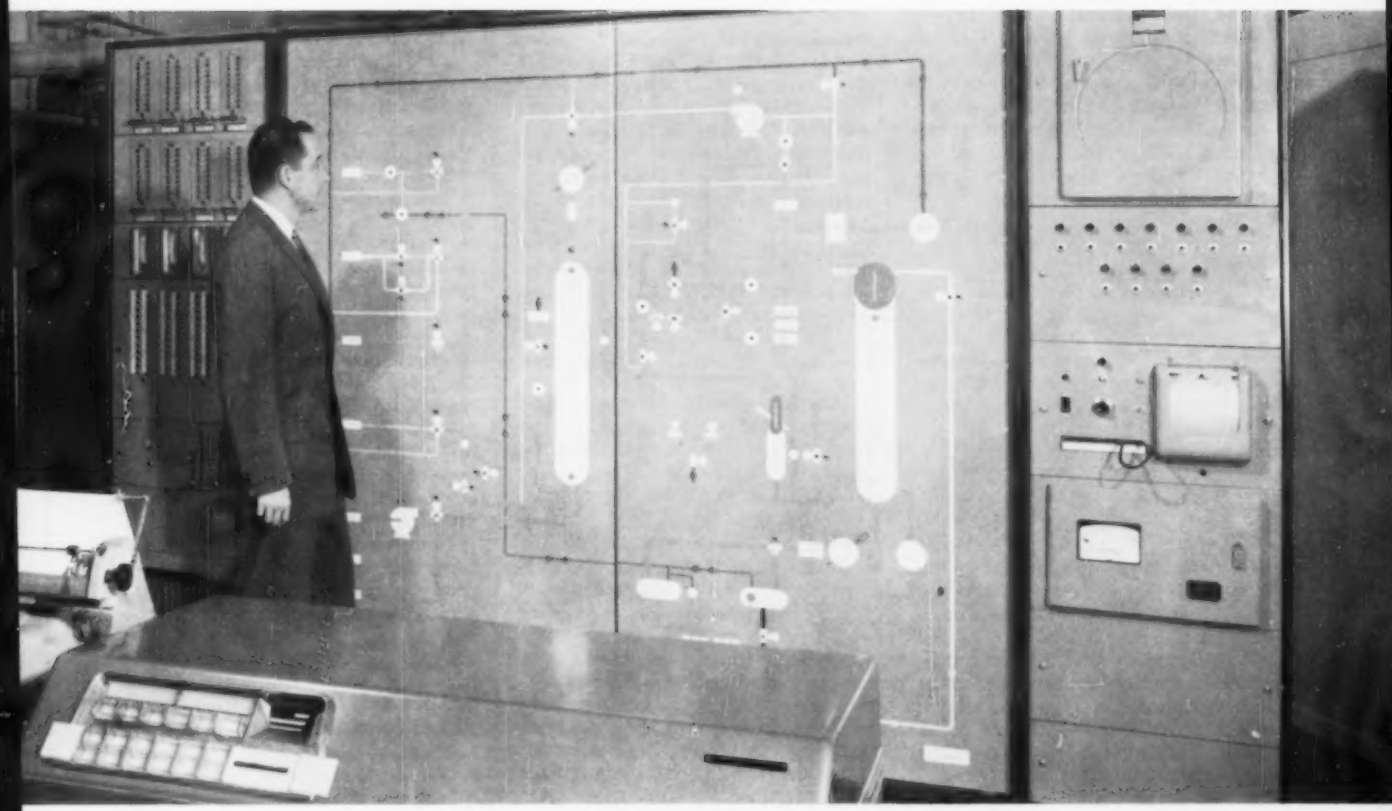


Digital or analog?

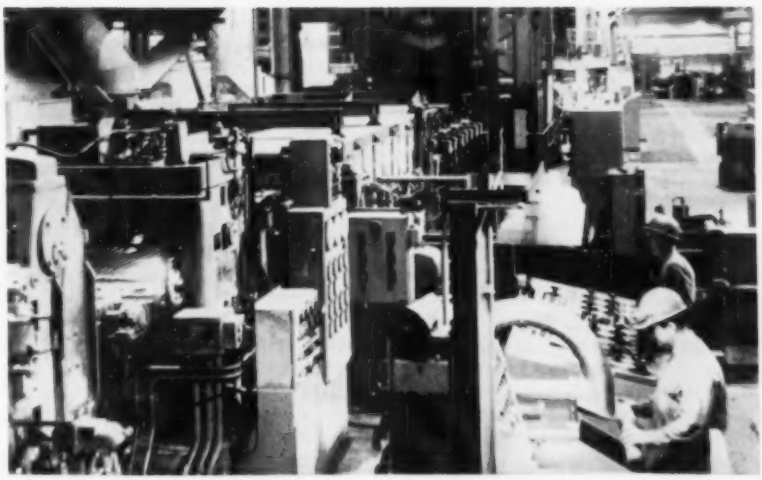
Of the two basic types of computers, digital and analog, each is most efficiently adaptable to certain types of problems.

A digital computer operates much like a desk calculator, but of course is much more advanced. Like the calculator, it performs repetitive tasks that can be reduced to a routine with great speed and precision. These calculations may be extremely complex and lengthy, but are always combinations of the basic arithmetical operations of addition, subtraction, multiplication, and division. The computer follows instructions exactly, is unlikely to misread numbers, and can operate at high speeds.

A digital computer's capabilities for solving any particular problem depend on the training, imagination, and ingenuity of the operator who instructs, or programs, it. Thus, programers must be certain that a complete and detailed solution of the



COMPUTER-CONTROLLED *pilot plant (above), the world's first fully automatic unit, measures, records, and controls temperatures, pressures, and stream compositions. Developed by Consolidated Systems Corp. and Esso Research & Engineering Co., the miniaturized unit is installed at Esso's Bayway refinery, Linden, N.J. The computer can make five control decisions per second. At right, punched cards containing production information are fed into a computer at the entry end of an annealing line at the Aliquippa, Pa. works of Jones & Laughlin Steel Corp. A corresponding identification tag then is sent to the line's discharge end, where additional data on the actual annealing process are typed on it by the computer.*



The process industries will use more computers for eliminating equipment, estimating costs, maximizing profits, and controlling

problem is possible by numerical methods.

An analog computer, on the other hand, uses electrical voltages to represent numerical values. Continuously variable values of functions are possible—in contrast to the numerical sequence inherent in digital computers. "Simulation" best describes the operation of an analog computer; physical systems are simulated by electronic circuitry.

The most important function that can be performed by an analog computer is integration. This is coupled with the capability for addition, subtraction, multiplication, and division of voltages that simulate numbers. Thus, differential equations can be simulated and solved without the tedious and time-consuming mathematical manipulation and numerical approximation necessary on digital computers.

Nevertheless, analog computers have several limitations. In the past, their operating speed has been limited by the electromechanical multipliers used for obtaining the product of two variables. That is, a variable changing too rapidly no longer would be represented by the mechanical motion of the servo. Electronic multipliers now are available which greatly extend the range of speed and frequencies over which an analog computer will operate. Despite this advance, speed still is limited by the electromechanical output recorders.

Set-up time for an analog computer may be shorter than for a digital computer, but a library of previously worked out digital programs often may eliminate many hours of labor. (See page 17.) Experience will increase the ability of an analog computer operator, but nothing comparable to a program library can be developed.

The usefulness of computers in the chemical process industries has been proved for activities ranging from basic research to plant trouble-shooting. Computers have been applied to basic research in the obvious areas of data analysis and correlation. Relationships too complicated in many cases even to be attempted by hand can be developed by machine. Standard programs to expedite the use of "least squares" analysis and empirical techniques in performing correlations have been made available for digital computers. Analog computers, on the other hand, seem to be more useful for determining actual behavior.

In studying rates of a chemical reaction, for example, the basic data must be correlated. For some purposes it is sufficient if an empirical relation describing the variation in reaction rate with the variables such as temperature, pressure, concentration, etc. is available. This type of relation can be obtained conveniently on a digital computer.

Simulating reaction mechanisms

However, for many design and operational needs, knowledge of the mechanism of the reaction may be required. An analog computer can represent the overall mechanism easily by simultaneously simulating the various steps in a reaction. Adjustment of each step will result ultimately in an acceptable explanation of the mechanism; it can be tested further and refined as more experiments are performed. The mechanism also might be determined with a digital computer by trial-and-error elimination. To accomplish this, every conceivable mechanism would be formulated and tested against available data. Acceptable mechanisms would be tested further until the actual mechanisms were determined.

Product development and improvement in the past required large doses of the "Edisonian" approach. Today computers simplify the task.

Consider the problem of improving the physical properties of a plastic. Normally, correlation requires many experiments to indicate which composition changes should be made. Essentially every possible or likely variation must be tried before the maximum improvement can be found.

However, experimental programs also can be run on computers. When programs are properly designed, the exploration of a limited number of definitive conditions may be all that's required to indicate the desirable compositions and their properties. It then becomes a simple matter to check the predictions by a short experimental program. Resulting improvements can be utilized directly to achieve a better product line, or they may be used again to refine still further the prediction of the improved composition.

Years condensed into months

The greater the number of possible variables, the greater, usually, is the value of using a computer to predict characteristics of potential products. Experience in many different areas of research has shown this. Several years of research effort can be condensed into a few months by using computers. And the savings in dollars are almost as great as the savings in time. Market gains are not so easy to estimate dollar-wise, but the advantages of being early on the market with an improved or new product are rather obvious.

Computers are particularly useful for pilot-plant studies, by making results and conclusions from an experimental run available almost as soon as the run is ended. Such efficiency of operation is not attainable in any other way. Moreover, studies can be carried out with greater ease by fewer operating personnel.

One example involved a computer program for analyzing results from a petroleum processing pilot plant. The computer was designed to exercise discretion in handling raw data; that is, it was to reject bad data points on statistical grounds and compensate for occasional missed readings, as well as produce the desired summary of information regarding the run. The pilot plant was a catalyst-testing unit with various process uses. Two important results derived from a run were data on the catalyst activity and the decline of activity with catalyst on-stream time.

Editing data as part of a manual calculation is no particular problem. However, scrutinizing tables for omissions and obvious errors, as is usually done, may be more time consuming than the machine computation. It is desirable to make the editing of routine processing of plant information part of the computing

pilot plants, designing automatic plants.

program so that test data may be read directly into the computer.

Eliminating the pilot-plant

Several large chemical companies recently have suggested the possibility of eliminating the pilot-plant stage in process development by simulating part or all the equipment, on any scale, by means of computers. This thesis has not been verified by any significant number of successful examples. Yet, it is a logical consequence of computer applications already being performed successfully.

Process simulation might follow these steps: experimenting in the laboratory; analyzing the resulting information to explain basic mechanisms of the chemical process; if proved on the laboratory scale, simulation on any scale desired. To operate a pilot plant then would require only selection of the proper scale of operation and of operating conditions to be tested.

The advantages would be considerable. By simulation alone, a poorly operating piece of equipment could be replaced by another more desirable one. Moreover, a large number of alternative designs could be compared quickly, easily, and inexpensively.

The big question—the degree of assurance that can be placed on results obtained from a computer-simulated pilot plant—has not yet been answered satisfactorily. Getting the answer probably will cause some delay in eliminating many pilot-plant activities. More research will be needed to simulate even some of the simpler processes.

Once a chemical process is conceived, its proper control becomes important. Normally, some elements of the control system for a process are developed during pilot-plant operation, but most instrumentation is specified by design engineers experienced in similar processes. Then, during plant start-up and initial operations, control points are set, monitoring points are adjusted, and many other necessary modifications are made in the instrumentation. Today, serious difficulties in plant

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start-up frequently are due to improper or inadequate process controls.

The computer provides the means for building an electronic model of the chemical process to be controlled. Models of several alternative control systems also can be simulated with the computer.

Since the computer model can be operated faster than real time, the control system to be used and the optimum value of control settings can be chosen quickly—much quicker than performing the same functions during actual plant start-up.

Use of computers enables this study to be finished before construction of the plant, so that modifications in plant design to facilitate instrumentation and control can be made economically. In addition, the computer model of the chemical process, operating in real time, can be controlled by actual equipment specified for the plant. Design of the control system can be proved and operating personnel trained at the same time. This leaves only final minor adjustments to be made in the control systems during actual plant start-up.

Repetitious calculations required for the design or sizing of many pieces of chemical-process equipment are completely adaptable to computer calculation, particularly digital types. Many companies have available or are developing digital programs for performing calculations required to design distillation columns, heat exchangers, and several other types of equipment. The economics of this type of computer use have proved favorable, and such use is expected to expand.

As a logical following step, a number of designers have proposed that the cost of chemical-process equipment and plants should be estimated by computers. However, no comprehensive or large-scale application of such methods is yet in progress. The primary reason is the complexity of the problem and resulting high initial cost of programming a digital computer.

An additional reason appears to be the proprietary and competitive nature of cost figures, precluding a cooperative effort by several engineering, design, and construction organizations.

Automatic plants

The ultimate application of computers in the chemical-processing industry will be for automatic plant control—a logical extension of simulation and control studies. In essence, automatic plant control depends either upon the availability of an accurate plant simulation with which to compare the actual operation, or upon the detailed and intimate knowledge of the interrelationships of many variables.

In either case, proper operation of the plant will depend upon the speed and accuracy with which a computer can determine a present operating situation, predict a future operating situation, and make necessary changes in the control system to assure satisfactory operation.

Both digital and analog computers will be found useful in achieving automatic control. In many cases it may be necessary to utilize both types simultaneously to achieve the required results efficiently.

Announcement has been made recently of several pioneering, largely experimental, installations of computers for controlling chemical processes. Among the processes have been: catalytic reforming, dehydrogenation, distillation, and the production of vinyl chloride monomers. Computers were devised or modified especially for controlling the various processes.

One of the serious problems delaying automatic process control is the need for instrumentation to provide accurate information on process variables. Meters for measuring temperatures and pressures are adequate, but we have no simple and effective device for determining the chemical composition of process streams.

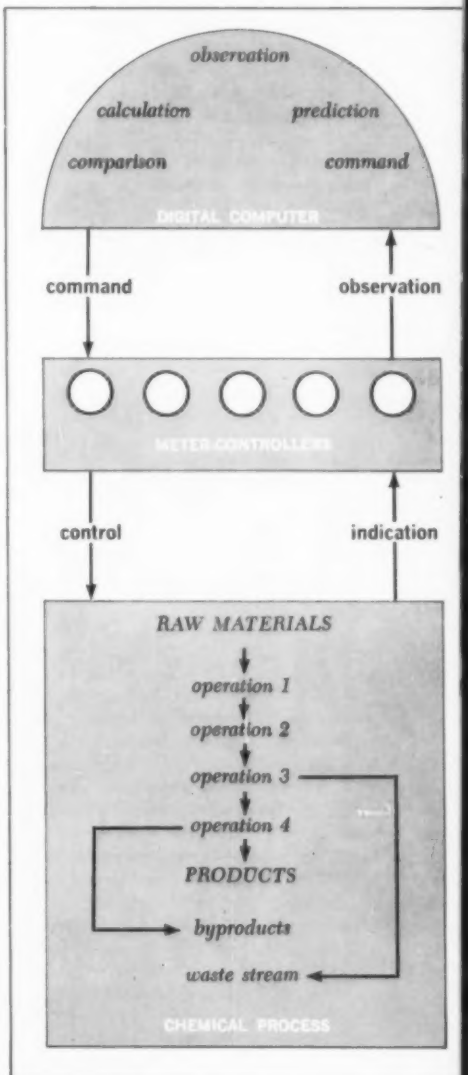
A hypothetical process

An example of a hypothetical chemical process and the control and computer systems required for its operation is shown in the diagram at right. Signals representing conditions (temperature, pressure, composition, etc.) in various parts of the process are metered by instruments and reported to the computer.

The conditions are utilized to compute required changes in the operating variables. When the required changes are known, command links are activated and operating conditions changed by means of process controllers, achieving the objectives without human interference.

In the simplified diagram, the term "desired optimum operation" was used to indicate an operational condition that would be best for some reason. The best condition almost always is defined as a certain economic condition—almost always the requirement for maximum profit.

Fortunately, computers can handle the maximum profit requirement in complex forms. They can be instructed to predict consumer demand for co-products as related to the time of the year, for example. Or, they can predict the best blend of raw materials as determined by their prices; the yield obtainable from each can be factored to yield maximum profit. If the computer is given instructions and information upon which to act, it is capable not only of controlling the process, but of determining optimum economic operating conditions.



CHEMICAL PROCESS *with hypothetical control and computer system receives signals on variable conditions, computes changes needed in operations, and automatically orders desired reforms.*

Computers and miracles

Computers cannot accomplish miracles. In the development of logic systems, a computer capable of original thought has not been invented. Consequently, men still must instruct the machine what to do, examine the results obtained, and draw the conclusions.

What are the requirements for a staff that will utilize a computer's capabilities most fully?

A suitable staff can be developed by training interested and qualified personnel, or by hiring experienced people. To be effective, a staff must be able to think in terms of the computer, its capabilities, and limitations.

For example, it has proved difficult to have mathematicians analyze problems which require the understanding of an engineer. It is equally unrewarding to have an engineer prepare problems for a computer without an understanding of its idiosyncrasies. A cooperative effort is required, and an appreciation of the varied disciplines, for optimum utilization of this complex tool must be established. Engineers less influenced by tradition and better prepared in mathematics often are more adaptable to this required combination of disciplines.

Traditions of engineering and technology are hard to overcome. An organization's philosophy must be one of continual encouragement if optimum utilization is to be accomplished. To make the computer an effective tool, the overwhelming advantages of its use must be demonstrated at every opportunity.

Many problems associated with the use of computers in the chemical industry remain to be solved. But a beginning has been made, and we can expect that more and more processes will be placed under computer control. Yet, process control is only one aspect of the usefulness of this instrument. Computers can aid in basic research, product development, pilot-plant operations, process studies, equipment design, and cost estimations.

With growth of knowledge, economic advantages of computers are becoming clear. It appears now that savings in labor costs will be unimportant. The real gains will arise from highly efficient operations—maximum productivity from plant investment with minimum operating costs. More experience is needed, however, before the true worth of computers can be evaluated. Data from the pioneer efforts now under way will play a significant role in guiding future developments. ■

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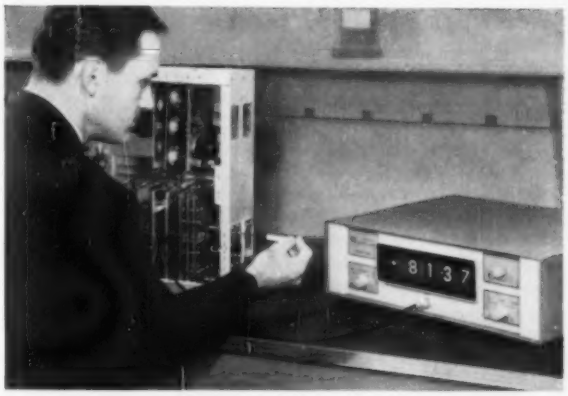

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BOEING SUBSIDIARY

by **Dr. S. H. Wittwer** *and* **Dr. M. J. Bukovac,** *department of horticulture, Michigan State University*

the stunted growth of GIBBERELLIN

THE CHEMICAL AGE in agriculture is just beginning, and with it the use of what some have double-termed a "growth" chemical — a jack-and-the-beanstalk plant regulator that itself is expected to grow and grow until it provides the chemical industry with a billion-dollar annual market. The plant regulator actually is a group of chemicals, known generically as the gibberellins, and is produced now after five years of intensive research only in very small quantities.

That these chemicals can stimulate growth in almost any plant is now beyond a doubt. But whether gibberellin ever will be used and produced in large quantities within the next decades is extremely questionable.

Diseased rice grew tall

The story of gibberellin began in the Orient about 35 years ago when a Formosan scientist, E. Kurosawa made an important discovery. He observed a peculiar fungus (*gibberella fujikuroi*) disease on rice. The infected plants (see photograph below) grew taller than their neighbors and then died.

Kurosawa found that when sterile, cell-free filtrates of the fungus were sprayed on rice seedlings, they produced the same over-growth as that caused by the disease. Attempts were made to isolate the active principle.

It was not until 1938, however, that T. Yabuta and Y. Sumiki, after years of effort at the University of Tokyo, successfully isolated the active principle in a crystalline state. Important as this discovery was, it aroused little attention. Neither the Japanese nor the rest of the world then realized the vast potentialities that gibberellin would have for modifying the behavior of large segments of the plant kingdom.

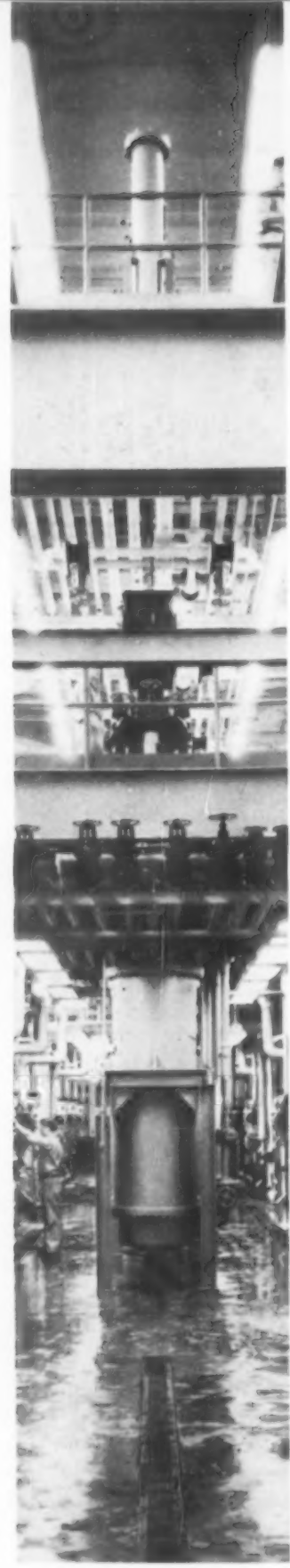
After 1950 scientists outside of Japan began paying attention to gibberellin. Chemists at Imperial Chemical Industries in Britain and the U.S. Department of Agriculture repeated certain phases of the Japanese work and almost simultaneously isolated gibberellic acid (gibberellin A_3). Even then it was not until 1955 that a few isolated groups of plant scientists in the western world began to study gibberellins seriously.

The nine gibberellins

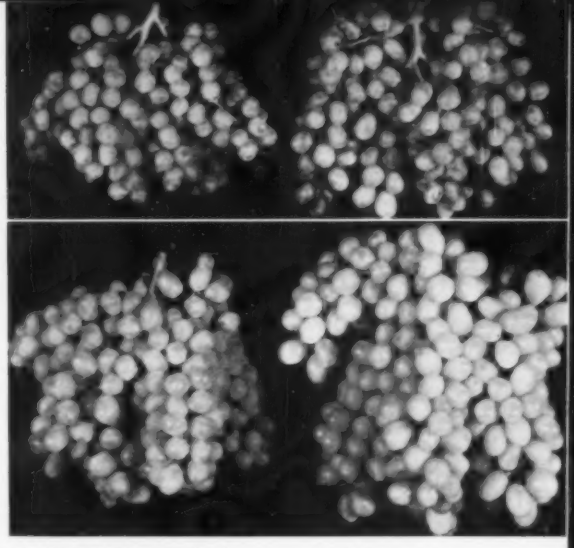
So far, nine active compounds—gibberellin A_1, A_2, A_3, A_4, A_5, A_6, A_7, A_8, and A_9—have been separated and chemically identified in plant materials. Gibberellins A_2, A_3, A_4, A_7, and A_9 all have been isolated from the soil-borne disease producing fungus on rice. Gibberellins A_5, A_6, and A_8 have been separated from immature seeds of the scarlet runner bean. Gibberellin A_1 has been isolated from the fungus, the scarlet runner bean, and water sprouts of citrus.

Limited commercial production of gibberellin in the U.S. has been a reality from the time it was first introduced and distributed for use

DISCOVERY OF GIBBERELLIN *followed observation that rice plants infected with "foolish seedling" disease grow taller, then die. Tall fungus-attacked plants were photographed by Dr. Y. Sumiki, University of Tokyo co-discoverer of active principle causing the unusual growth.*



FERMENTING TANK *for production of gibberellic acid at Abbott Labs (left and above) is basically same equipment as is used in manufacture of antibiotics. Interchangeability will permit almost unlimited production of gibberellin to meet future demands if use becomes widespread.*



SPRAY TREATMENT *of Thompson Seedless grapes increased berry size in University of California test photographed by Dr. R. J. Weaver. Grapes received 5 ppm gibberellin spray (lower left) and 50 ppm (lower right). Grapes at top were unsprayed.*

Gibberellin can stimulate almost every plant,

on flowers in 1957. Fermentation equipment used in the production of antibiotics can be adapted easily for gibberellin — hence interest in the chemical among antibiotic manufacturers.

Potential production virtually is unlimited. Still it is probably the most costly chemical ever manufactured for agriculture. The molecule is very complex, and chemical synthesis appears a long way off.

Four companies in this country— Abbott Laboratories, Charles Pfizer, Eli Lilly, and Merck & Co. are licensees of the English ICI, which owns the basic "composition-of-matter" patents, and active programs for developing commercial uses have been conducted by each. From an original cost of $40 a gram, the chemical now wholesales for about 5% of the original price. With increasing demands further price reductions can be expected.

Jack and the beanstalk

Many unusual effects of gibberellin on plants have been observed. Increased stem elongation was the first and still the most generally noticeable response. Treated plants grow taller, sometimes abnormally tall. There is a stepwise growth response over a very wide range of concentrations, and as little as one-hundredth of a microgram of gibberellin increases the rate of stem elongation in the bean plant. Leaf size, flower size, and earlier flowering have been increased on some plants consistently.

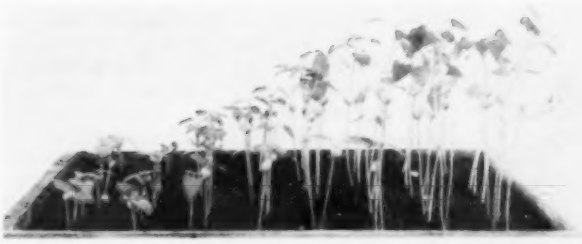
The growth of many plants is greatly stimulated with gibberellin in cold weather when otherwise there would be no growth. Adequately fertilized lawn grasses and turfs will develop to a lush green in early spring two to three weeks in advance of the normal season from doses of a few grams of gibberellin per acre. Aside from the novelty, earlier growth and greening of golf course turfs can become commercially significant.

Growth of otherwise vestigial or dormant buds can be promoted on a variety of crop plants such as cotton, potatoes, strawberries, and coffee. This not only may contribute to the total fruiting capacity of the plant, but a uniformity of growth and fruiting previously impossible may be achieved.

The most striking results so far have been with seedless grapes; the berries are larger, and the clusters less compact.

The size of seeded grapes also is increased, and the fruit may ripen and color earlier. Significant increases in fruit-setting of some pear and apple varieties have been reported. Gibberellin-sprayed citrus fruit has thinner rinds, more juice, and a higher vitamin C content.

Many seeds germinate earlier and there is a more rapid growth of seed-



SEEDS EMERGE *earlier if treated with gibberellin, whether in laboratory, greenhouse, or field. Beans (above) show relative effects, left to right, of no treatment and of applications of increasing concentrations. Geraniums (right) have larger, longer-lasting flowers if gibberellin is applied to buds. Control blossoms, which were untreated, are shown at left.*

Horticulturist Dr. S. H. Wittwer stands beside 12-foot cabbage grown with gibberellin at Michigan State, where he has been teaching, researching, and writing since 1946. He is a PhD graduate and former faculty member of the Univ. of Missouri. Dr. M. J. Bukovac (lower left), Michigan State PhD, has been a member of the university's faculty since 1956, specializing in the physiology of flowering and fruit growth.

but FDA regulations have slowed its commercial development.

lings. Cotton, sorghum, wheat, and direct-seeded tomatoes have responded favorably to seed treatments.

Gibberellin has many other direct or indirect effects on plant behavior. Wintertime growth of plants grown under short day-lengths is improved greatly. Thus, significant increases in yield of celery, spinach, and other leafy vegetables may occur in fall and winter vegetable growing areas.

But certain harmful effects, including twisting of the stalks, more rapid development of seedstalks, a shorter harvest period, and increased breakdown in storage, may outweigh the benefits. Top growth is favored over root growth, and stem growth over leaves.

Dwarf varieties of peas, beans, corn, cotton, and tomatoes when treated with gibberellin grow as tall varieties. Spider mites fail to reproduce normally on gibberellin-treated bean plants.

Mechanical harvesting made easy

Mechanical harvesting of spinach can be facilitated because the leaves of treated plants turn more upright within one to two days after treatment and can be clipped with greater ease. Similarly, mechanical harvesting of pickling cucumbers is aided because gibberellin-treated plants produce their first pickles farther out on the runners and fruit-setting at the crown is eliminated.

A particularly interesting flowering response that can be controlled with gibberellin is in the cucumber. Cucumbers that produce only female flowers have been developed. Staminate or male flowers have been induced on these otherwise completely female flower-producing plants following foliar sprays of gibberellin. In fact, complete flower sex reversal has been achieved experimentally.

An application of this phenomenon has been suggested as an easy way to develop hybrids in other crops, by making one parent strain all male, the other all female.

One of the potentially important developments of gibberellin is its formulation with various fertilizer salts and plant foods. Gibberellin-treated plants grow at greatly accelerated rates, soil nutrient supplies are quickly exhausted, and the plants turn a yellowish green. This can be partially or almost completely avoided if nutrient levels are high or if fertilizer salts are applied in combination with gibberellin.

Animal growth promoter?

The most recent speculation in the applications of gibberellin is as an additive to animal feed. A patent for using gibberellin to stimulate animal growth now has been issued to three Indiana researchers—John R. DeZeeuw, Gerald A. Donovan, and William C. Sherman—who have assigned it to Charles Pfizer.

The inventors claim that a very small amount of gibberellin, between one part in a billion and one part in a million, significantly increases the growth rate of poultry and also is effective for cattle, sheep, pigs, lambs and other farm animals.

The compounds used for this purpose are gibberellins A_1, A_2, and A_3, which have been more successful in promoting animal growth, according to the patent holders, than have such materials as penicillin and stilbestrol. However, use of these older additives still may be necessary, in conjunction with the non-antibiotic gibberellin, to reduce the incidence of disease in at least some cases.

(The research departments of other manufacturers report they have been unable to produce any noticeable effect using gibberellin on animals—either microorganisms for antibiotic use or the higher animals.)

Be this as it may, we may project that many of the agricultural uses of gibberellin will be unlike those of other chemicals. Possibilities for gibberellin probably lie in yet unexplored areas of chemical regulation. New uses will not be realized hastily, nor will they develop without disturbing side effects that may be decidedly damaging unless certain fertilizer and harvesting practices are adjusted. Herein, however,

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lies the challenge for the future.

Four to five thousand acres of California seedless grapes have been sprayed in 1960, and a like amount of cotton seed treated or plants sprayed. Trial acreages of grass, celery, coffee, wheat, citrus, sugar cane, and potatoes have been treated.

But in each crop the treating objective is different—grapes for larger berry size and increased yields, cotton for earlier seedling emergence, grass for earlier spring, growth etc.

1st commercial use: malting

The first important commercial usage of gibberellin appears to be in the malting industry. Only one gram of gibberellin per ton of barley, or one part per million in the steeping water, is required. Gibberellin greatly reduces germination time, and increases the alpha amylase activity beyond that which could be secured even by a greatly extended period of germination. The result is a dry malt with high amylase activity.

Little is known of the comparative effects on growth, flowering, and fruit-setting of the nine known gibberellins. Commercial production until now has been almost exclusively gibberellin A_3 (gibberellic acid), accompanied by a small amount of gibberellin A_1. This has been wise because for most plant responses gibberellin A_3 is by far the most effective of the gibberellins.

Recent tests, however, have revealed that gibberellin A_4 is approximately 10 times more effective on cucumbers than A_3, and this has been confirmed for seed germination in tobacco and leaf expansion in the bean and radish. At this writing the only source for gibberellin A_4 is the laboratory of Dr. Y. Sumiki at the University of Tokyo in Japan.

The market potential

Forecasts of the market potential for gibberellin range from enthusiastic to cautious. One of the most optimistic predictions has come from *Fortune* (April, 1959), which called gibberellin the "most interesting" of a new group of chemical growth regulators that "within a decade or two . . . will probably provide the chemical industry with a billion-dollar-a-year market."

A more conservative view has been expressed by Norman Leffler, product manager of industrial and medical chemicals for Abbott Laboratories, which manufactures gibberellin for marketing by Velsicol Chemical Co.

Leffler, who does not see a large market for gibberellin in the near future, points out that general use of the compound for each plant must be cleared individually with the Federal Drug Administration under the Food Additive Amendment law. So far, only one use — malt — is cleared, and further clearances may be expected to come slowly because of the necessity for proving gibberellin's non-toxicity in food residue, an extremely difficult task in view of the minute quantities (in the order of 0.001 parts per million) involved in the residues.

The gibberellins apparently are "safe" chemicals for use on food crops. No unpleasant or otherwise noticeable effect on the user ever has been reported. When applied to plants they are readily absorbed, but remain highly systemic and are not stored in any particular part. Massive dosages far above those that possibly could be encountered with treated food crops have proven harmless to a wide selection of test animals.

Finally, gibberellins occur naturally in some and perhaps all higher plants. The gibberellin applied in crop production is, therefore, merely additive or supplemental to those that are plant produced.

However, government restrictions persist, and the main concern at present is to get gibberellin cleared through the FDA for use on grapes. Extensive experiments with seedless grapes have produced superior-quality fruit which has commanded prices 50% above the market in New York's produce center. Because of success in growing better crops, experimentally, efforts will be made to get early FDA clearance on oranges, lemons, tangerines and celery.

Once FDA requirements have been met on these items, agricultural use of gibberellin will increase. For example, a very practical application of the compound will be in the growing of the hybrid Orlando tangelos (a cross between a tangerine and a grapefruit), a premium citrus fruit which sells at a high enough price to offset the expense of gibberellin treatment.

High cost, difficult usage

But the marketing problem for gibberellin is not limited to government regulations. Also involved are the comparatively high cost of the product and certain difficulties in using it properly.

From the standpoint of economics, for instance, it does not seem practical to apply gibberellin to mass crops such as corn because the effect is not great enough to overcome the expense of the chemical. The same is true for use on trees, which must be treated repeatedly

for effective results since gibberellin's stimulating power on trees wears off rapidly.

Perhaps even more important as a use-limiting factor is the fact that gibberellin treatment must be specifically tailored to each plant—even different varieties of the same plant sometimes react differently to the compound—and to each set of growing conditions. For example, when the weather is cold and dry, cotton can be stimulated favorably with gibberellin, but when conditions are warm and humid, cotton plants are affected unfavorably by the chemical.

Thus, complications of using gibberellin effectively are too involved for the average home gardener, which eliminates any do-it-yourself market for the product. A few years ago when publicity on gibberellin was particularly widespread, small packages were put on the retail market and enjoyed a brief popularity in sales to the nation's thousands of weekend farmers. But the difficulties of knowing just where, when, and on what to use gibberellin, and a few poor results therefrom, have reduced the small-package business to a bare trickle.

The limits of food production

While the difficulties in use and the expense of production seemingly are built-in limiting factors to gibberellin's market growth at present, many scientists now are busy on these problems, for gibberellins are unique chemical agents for controlling many aspects of plant behavior, and have served as a major scientific breakthrough in plant physiology.

Gibberellins offer control of important plant responses — elimination of dwarfism; elongation of stems; increased top-root and stem-leaf ratios; expansion of leaves; production of dry matter; increased fruit-set on grapes, Bartlett pears, Navel oranges, and some varieties of apples and cotton; acceleration of flowering in biennials and long-day annuals; induction of normal growth rates at sub-optimal temperatures and photoperiods; control of flower sex expression in cucurbits; and finally a means of regulating enzyme production, germination, and seedling emergence of many seeds used in industry and agriculture.

As a chemical approach in mediating the effects of temperature, light, photoperiod, and nutrition, gibberellin one day may cancel out many of the uncertainties of season and weather, thereby radically extending the boundaries and magnitude of crop production. ■

with **CHROMALLIZING**

Oxidation and thermal shock resistance of metals used in jet engines and similar superheat applications are greatly improved with CHROMALLIZING. The patented and proven process of diffusing chromium with other elements into the surface provides an alloy case which is integral with the base metal. It can't peel or flake; the chromium and other elements diffuse uniformly into recesses, pores, cracks and even blind holes.

Alloy	Usual Operating Temperature	Operating Temperature of CHROMALLIZED Alloy
Iron Base (including stainless steels)	1500° F	SA CHROMALLIZED 310 and 321 stainless steels show no failure after 18 hours at 1950° F in an atmosphere containing lead bromide and lead sulfide.
Nickel Base	1800° F	U CHROMALLIZED nickel base alloys are unattacked after 200 hours at 2000° F.
Cobalt Base	1800° F	SAC CHROMALLIZED cobalt base alloys are unattacked after 150 hours at 2200° F.
Molybdenum	Over 2000° F	W-2 CHROMALLIZED molybdenum shows no failure after 400 hours at 2350° F, after 48 minutes at 2800° F, and after one minute at 3400° F.

Ordinary steel can also be chromallized to provide resistance to corrosion, oxidation and wear.

A recent Chromalloy development, IOCHROME (99.997% pure chromium), is a basis for chromium alloys for use at 2500°F.

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CHECKLIST FOR MORE INFORMATION

New products

☐ SILICON POWER TRANSISTORS now are available for those applications where you need more transistor power, extra long life, and greater stability under all operating conditions. Nine new devices, each rated at 30 amps, permit greater flexibility of circuit design in high-power applications. Write to Dept. SC-1012, Westinghouse Semiconductor Dept., Youngwood, Pa.

☐ A MAJOR CAUSE OF TRANSISTOR FAILURE can be eliminated by building a transistor inside its own shell. The new method, called "Planar Structure" is explained in a 12-page brochure available from Fairchild Semiconductor Corp., 545 Whisman Rd., Mountain View, Calif.

☐ SILICONE FLUIDS developed by Dow Corning make it possible to design more efficient mechano-fluid devices. They are resistant to oxidation, are non-gumming and non-sludging, and are serviceable at temperatures from −100 F to +400 F. Write for a descriptive brochure to Dept. 4412, Dow Corning Corp., Midland, Mich.

☐ MAXIMUM OSCILLOSCOPE SENSITIVITY can be used to display small segments of large waveforms with the new type-Z plug-in unit offered by Tektronix. The unit also acts as a conventional preamplifier and a differential-input preamplifier. Write to Tektronix Inc., P.O. Box 500, Beaverton, Ore.

☐ COMPOUNDING JOBS can be done less expensively with Aroclors developed by Monsanto. A 44-page booklet outlining electrical, mechanical, chemical, and specialty uses is available by writing Dept. 2734, Organic Chemicals Div., Monsanto Chemical Co., St. Louis 66.

☐ NEW VACUUM GAGE measures pressures in two ranges, from 3,000 microns to below 10^{-7} mm Hg. Send for bulletin 3811.1, Kinney Vacuum Div., 3526M Washington St., Boston 30.

☐ ULTRASONIC CLEANING now can be done efficiently with cleaners that are continuously self-tuned electronically. Send for booklet 60-1, "How to Clean Ultrasonically with Self Tuning," Dept. IR-1, Powertron Ultrasonics Corp., Patterson Pl., Roosevelt Field, Garden City, L.I., N.Y.

☐ AUTOMATE YOUR ANALYSES on a new nondestructive analyzer that uses principles of radio-frequency spectroscopy to make measurements. A detailed 12-page brochure is available from the Ridgefield Instrument Group, Schlumberger Corp., Ridgefield, Conn.

☐ PRESSURE-TO-VOLTAGE SYSTEM incorporating only one moving part gives you all advantages of a variable-reluctance transducer without the disadvantages of AC transmission. Write for complete specs to Ultradyne Inc., P.O. Box 3308, Albuquerque, N.M.

☐ ENGINEERING TRAINING can be made easier with the new Automat 25A set, allowing trainees to construct their own three-dimensional model mechanisms. Write for catalog to Dept. M-1777, Science Materials Center, 59 Fourth Av., New York 3.

Ideas

☐ YOUR COMPUTER NEEDS can be served better via the 11 new information processing centers which will be opened within the next year and a half throughout the nation by General Electric. For more information, write to the GE Computer Dept., 13454 N. Black Canyon Hy., Phoenix.

☐ AN ELECTRONIC COMPUTER ordinarily is a large expense. But Bendix Computer has information showing how at a low initial investment, without adding special personnel or facilities, you can start now to provide your firm with the money-saving speed and precision of electronic computation. For application and other information, write to Bendix Computer Div., Dept. Y-28, Los Angeles 45.

☐ EXPANSION-MINDED COMPANIES might consider Massachusetts for exceptional human and climatic resources. For detailed, factual information, write to Massachusetts Dept. of Commerce, 150 Causeway St., Boston.

☐ PLANT-SITE PROFILE on New York, the most comprehensive ever done on an industrial state, is available describing labor, markets, raw materials, power, transportation, financing, etc. Write Comm. K. S. McHugh, Dept. of Commerce, Rm. 851, 112 State St., Albany 7, N.Y.

☐ LABORATORY SPACE CAPSULE—designed to measure man's physiological and psychological limits and test life-support systems under simulated space-flight conditions — has been developed by Garrett for WADD. For more information about this and about employment opportunities, write The Garrett Corp., AiResearch Mfg. Divisions, Los Angeles 45.

☐ CHROMALLIZING, a process for diffusing chromium with other elements into the surface, provides an alloy case that is integral with the base metal. It can't peel or flake. Write for illustrated bulletin RH, Chromalloy Corp., 169 Western Hy., West Nyack, N.Y.

☐ PATENT FOR SALE covers novel, simple, sheet-metal products to be used by the electrical manufacturing industry. Market survey indicates sales would be in excess of $2-million yearly. Write to Box 705, Industrial Research, 200 S. Michigan, Chicago.

Employment opportunities

☐ KEY CAREER OPPORTUNITIES are offered to scientists and engineers in 10 technological fields by Allied Research, Boeing subsidiary. For a booklet describing facilities and capabilities, write Allied Research Associates Inc., 43 Leon St., Boston 15.

☐ THREE MANUFACTURING RESEARCH ENGINEERS are wanted to do original work with new materials. Send resume to Mr. T. H. Tillman, Box 303-QT, The Bendix Corp., 95th & Troost, Kansas City 41, Mo.

RESEARCH

TRENDLETTER

Dec-Jan, 1960-61

Dear Sir:

Industrial development in foreign nations, much of it sparked by their growing research activities, is stimulating U. S. industry by providing both competitive challenge and new products and processes adaptable to industrial operations. (See special section of this issue, beginning on page 46.)

One of the latest new advances is a lubricant for use in metal-forming processes at temperatures between 1100 and 2200 F, developed by a large steel manufacturer in Germany and available in the United States from Alpha-Molykote Corp., 65 Harvard Av., Stamford, Conn. The new lubricant, called Phosphatherm RN, is said to prevent galling, scoring, and metal pickup when forming most types of common steels, steel and copper alloys, and exotic metals at elevated temperatures, for which conventional lubricants often are ineffective.

The day may not be far off when executives' dictation will be transcribed directly by a phonetic typewriter operated by voice. Such a typewriter, the Sonotype, has been built at Kyoto University, Kyoto, Japan, and in early tests has scored more than 70% accuracy. To date the university's experimental model is limited to 100 monosyllables of the Japanese language, but research is underway to expand its range and to make it adaptable to other languages.

To meet foreign competition which now has 40% of the U. S. market in nails, a system for automatic packaging has been devised by Mead Corp.'s New Products Div., 4400 Marburg Av., Cincinnati. New system cuts nail packaging costs in half, uses powerful electromagnets to align nails as they fall down a chute into heavy-duty corrugated paperboard cartons. Mead expects the system eventually to be used for other metal and free-flow materials such as screws, bolts, shotgun shells, and even detergents.

computers

With electronic computers becoming more and more widely used by U. S. industry (see computer applications articles in this issue beginning on pages 14 and 20), another new application is for automatic control of the Riverside Power Station of Gulf States Utilities Co.

The first such installation in an existing electric generating plant, the system is expected to increase Riverside's flexibility and reliability in supplying power requirements. Prime contractor for the power station's modernization is Allis-Chalmers Mfg. Co., Milwaukee, which will design, furnish, and install the complete control system and also will modify existing equipment as required.

Communications & Control Corp., 14707 Keswick St., Van Nuys,

Calif., has begun production on its Model 1610 digital data system, which is designed to monitor and record data from an entire plant at high speed, replacing chart and strip recorders, and is said to provide higher accuracy. Communications & Control sees principal use of the 1610 in process industries, power distribution centers, and laboratories where large quantities of data are required at low cost.

For the first time an electronic data-processing system is being used to increase accuracy and efficiency in the delivery of telephone books. "Yellow-page" delivery orders are being turned out at the rate of 1,200 characters a second for New York Bell by RCA's 501 computer system from its six magnetic-tape memory units. By this method 9-million directories will be distributed in New York and suburbs. The computer system permits rapid updating of customer files, enabling Bell to make delivery order changes even while the books are being printed.

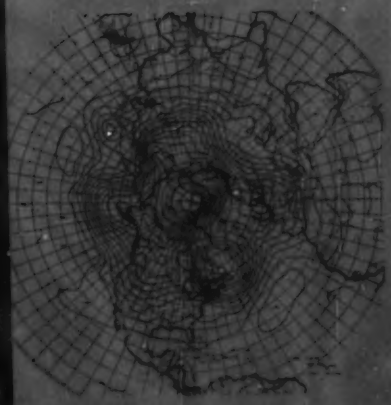
The U. S. Weather Bureau has put into operation an electronic computer "weather plotter" that mechanically draws a complete weather map of the Northern Hemisphere in less than three minutes. Developed and produced by Electronic Associates Inc., Long Branch, N. J., the unit reads weather information supplied in numerical form on magnetic tape. A digital-to-analog converter then instructs a "mechanical hand" to draw contours or isobars, representing lines of barometric pressure, on a 30 x 30-inch map of the hemisphere. (See drawing No. 1.)

materials

Ceramic-insulation materials capable of withstanding temperatures of more than 500 C have been developed by GE's Direct Current Motor and Generator Dept., Erie, Pa. For use in electrical systems of Mach 3 aircraft, as well as for future missiles and other space applications, the new insulation materials are of two types. One, for ground and phase insulation, is an inorganic sheet material, a composite of flake mica and glass cloth bonded together with an inorganic cement. The other, an encapsulating material, is a ceramic cement consisting of equal parts of magnesium oxide and glass frit, with a binder of aluminum phosphate in phosphoric acid.

Discovery of a new metallic compound with unique on-and-off magnetic characteristics has been reported by Du Pont, Wilmington 98, Del. The new material -- chromium manganese antimonide -- is a brittle, gray manganese compound. It becomes magnetic at temperatures above a point predetermined by its chemical composition, then becomes nonmagnetic at temperatures below that point. The temperature at which the compound becomes magnetic can be varied over a wide range by slight changes in the material's composition. The abrupt magnetic change occurs because the distance between the compound's atoms is varied. Thus a temperature change, causing the material to expand or contract, alters the distance between atoms and brings about the magnetic change.

American Machine & Foundry Co., 261 Madison Av., New York 16, has demonstrated three unusual new applications for its "tissuglas," all-glass insulating paper. (See photograph No. 2.) Potentially largest new use is in 1/16-inch-thick flexible electroluminescent panels which, AMF claims, give off light superior in brightness, clarity, and uniform texture. Tissuglas also can be used as a saturating base in the manufacture of bonded strain gages, where its ability to pick up resins in uniform thicknesses gives the gages uniform



1 2

3

resistance and high-temperature stability. In its third new use, tissuglas of one mil thickness can be laminated with 3/4-mil copper foil to produce the thinnest printed-circuit material now available.

electronics

An electronic reading and printing system, which makes it possible to transmit mail from one city to another in seconds, has been developed by Stromberg-Carlson and Haloid Xerox Inc., both of Rochester, N. Y. The system recently was tested extensively by the U. S. Post Office Dept., which used it for sending mail between Washington and Chicago. (See "Speedup in Office Copying" beginning on page 69, this issue.)

A completely automated operation which assures privacy of the mail, the system uses photoelectric or facsimile scanning to "read" letters, transmitting them via TV-type communications lines to the destination city, where an electrostatic printing device receives the message and reproduces it in black and white. This letter then is sealed and ejected from the machine, ready for delivery to the addressee.

IBM has announced development of two new tunnel diodes which promise far greater speed and reliability, and lower power use, for electronic computer circuits. One of the new diodes, which switches at speeds faster than 4/10ths of a billionth of a second, is intended for use in basic computer circuits known as binary triggers, where it should speed up arithmetic operations five to 10 times over previously designed units.

The other new diode also has high speed and other improvements which show promise for computer storage circuits. Design advances in both tunnel diodes come from a new fabrication method involving an electronically monitored and controlled etching technique. After a pellet of germanium (used for both diodes) has undergone its basic device packaging, the new automatic process, which assures uniform electrical characteristics in every unit, etches away the germanium until an almost microscopic pyramid remains. Photograph No. 3 shows the sizes of the two new diodes in comparison with the head of a paper match.

(The tunnel diode, a major advance in computer technology, was invented in Japan in 1957. See "Computer Progress in Japan," beginning on page 63, this issue.) For more information on the IBM developments, write to Howard K. Janis, IBM Research & Engineering Information, 590 Madison Av., New York 22, or Robert W. Slade, IBM Data Systems Div., Poughkeepsie, N. Y.

The "tunneling" electronic process used in the semiconductor tunnel diode has been observed for the first time in a simpler device at GE's Research Laboratory, Schenectady, N.Y. The device (see photograph No. 4) consists of two metal films separated by a thin insulating layer, with one or both of the metal films in the superconducting state (offering no resistance to passage of electric current).

GE reports that, while the discovery is too recent for full evaluation, it has opened a new approach to the construction of versatile, microminiature electronic components and may make possible a whole new family of electronic devices.

A new transistor has been perfected that makes possible production of all-transistor high-fidelity sound equipment on an economically practical basis, according to RCA, 30 Rockefeller Plaza, New York 20. The transistor -- which has an alloyed emitter, diffused collector, and graded base -- can be used in both Class A and B audio amplifiers, a job transistors previously have not been able to do economically.

Bell Telephone Laboratories, 463 West St., New York 14, has developed a system which performs electronically all functions of handling telephone calls. Photograph No. 5 shows test phone at administration center in Morris, Ill., where ECO (electronic central office), now on customer trial, permits subscribers to: use home extension phones as intercoms; reach frequently called numbers by dialing only two digits instead of seven; have incoming calls routed to another phone when the originally called line is busy; and dial a code to transfer all following incoming calls to any other number.

Services to be added later will allow the trial users to call a third party into an existing telephone conversation and to get immediate connection to a busy line as soon as it becomes available. Bell expects ECO to go into production in 1965 and to be worked into the company's system gradually from that time on.

Infrared

An infrared guidance sensor to control final orientation of U.S. space probes during flights to Venus and Mars now is being developed by Barnes Engineering Co., 40 Commerce Rd., Stamford, Conn. On such flights, planned for 1962, radio and inertial guidance will place the probes within 100,000 miles of the planets. Infrared terminal guidance systems then will take over to point the vehicles' measuring instruments at the planets.

Infrared Industries Inc., Waltham, Mass., soon will put on the market a new communication system which uses principles of missile detection and satellite observation to send telephone-like conversations hundreds of yards without wires. The "infraphone," which is powered by ordinary flashlight batteries and has a transistorized amplifier, will be sold through electronic supply houses, sporting goods stores, marine supply outlets, and hobby shops.

An infrared kit enabling Army tanks to operate at night is under development at the U.S. Army Engineer Research & Development Laboratories, Ft. Belvoir, Va. The kit will include an infrared-visible xenon searchlight, a gunner's infrared-visible periscope, a commander's infrared periscope, and a hand-held infrared binocular.

The searchlight is to be mounted to operate in unison with the tank gun, and the beam will be variable in width and intensity. Infrared radiation will illuminate objects so they can be observed by the periscopes and binoculars.

A newly designed slide rule reduces the number of steps necessary to figure radiation from a black body. The slide rule, which in many instances provides information with one setting of the slide and/or cursor, is available from Walsh Engineering Sales Co., Inglewood, Calif.

Power

An experimental reactor to test use of a molten uranium salt as fuel will be built by the AEC at Oak Ridge. This type of reactor -- said to offer cost savings by operating at higher temperatures and producing electrical power more efficiently than conventional reactors -- also eliminates expense of fabricating fuel elements and simplifies reprocessing of spent fuel.

The experimental model, to be in operation by 1963, will cost $4.1-million. It will produce a maximum of 10,000 kilowatts of heat, but no electric power will be generated.

A low-powered, propane-fueled thermoelectric generator system for the Navy's first unmanned ocean-based automatic weather station is being designed and built by General Instrument Corp. under contract with the National Bureau of Standards. The weather station is located 300 miles offshore in the Gulf of Mexico.

A completely gas-operated fuel-cell power pack to generate electricity directly from natural gas, water, and air, is under development at the Inst. of Gas Technology, Illinois Inst. of Technology, Chicago 16. To produce 10 kw, such a power pack will be about the size of a gas furnace. Heart of the unit will be a number of thin high-temperature cells, generating electricity by a direct electrochemical reaction.

new processes

Continuous rolling of strip from powder has become a reality with the first production unit for direct compacting of powder by Metals for Electronics Inc., 1331 Dixwell Ave., Hamden 14, Conn. Output to date has been limited to nickel strip.

The world's most powerful x-ray machine, specifically designed for high-speed radiography in the metals industry, will be installed this spring at A. O. Smith Corp.'s Milwaukee plant. The 8-million-electron-volt linear accelerator is being built by High Voltage Engineering Corp., Burlington, Mass. The machine, called the Linac, will "see" through steel more than a foot thick and will furnish photographic proof of the soundness of such metal structures as core barrels for nuclear reactors and high-pressure vessels.

A 1-million-gallon per day plant for conversion of sea water to fresh water will be constructed for the U. S. Dept. of Interior's Office of Saline Water by Westinghouse Electric Corp., Box 2278, Pittsburgh 30. The plant will be located at Point Loma near San Diego, Calif., and its daily fresh-water output will be purchased by the city of San Diego.

World's first completely automated coal-fired steam electric power plant is being built at Goldsboro, N. C., for the Carolina Power and Light Co. A computer will both start up and shut down the plant and will include analog sub-loop controls. Called the Sparc (steam, power, automation, results, computer) system, it is being supplied by Daystrom Inc.'s Control Systems Div., Murray Hill, N. J.

now available

Cryogenics Inc., 1129 Vermont Av., N. W., Washington 5, D.C., has new vapor-pressure thermometers for high-accuracy determination of temperatures over small spans in the low-temperature regions. A sensing element contains a gas such as helium, oxygen, or hydrogen, which is liquified at some temperature in the range of interest, 20 to 150 K. Response time is less than 200 milliseconds.

All-acrylic electroluminescent panels are being produced by Controls Co. of America, 1420 Delmar Dr., Folcroft, Pa. Panels are completely machinable and offer great flexibility in application.

Smallest known strain-gage transducer is produced by Statham Instruments Inc., 12401 W. Olympic Blvd., Los Angeles 64, Calif. Described as a microminiature, flush-diaphragm transducer with high-frequency response, it is smaller than a dime and weighs only 0.5 grams. Ranges are 0-10 psi to 0-100 psi, in absolute, gage, or differential pressures. Ambient temperature limits are -65 to +150 F.

A new transistorized voltage comparison amplifier made by Non-Linear Systems Inc., Del Mar, Calif., is said to provide a precise, fast, and reliable way to determine if an input voltage or series of input voltages is within preset limits. Colored bulbs light for visual indication and relays operate external warning and control devices within 90 milliseconds after applying the voltage under test.

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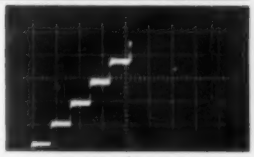
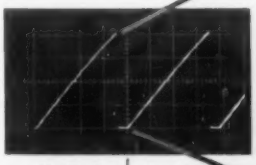
Vertical Expansion 500 Times

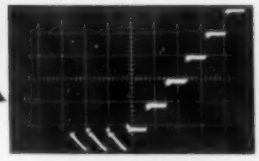
Horizontal Expansion 500 Times



Vertical	Horizontal
50 mv/cm	10 μsec/cm
V_C = +92.5	



Vertical	Horizontal
25 v/cm	5 ms/cm
V_C = 0	



Vertical	Horizontal
50 mv/cm	10 μsec/cm
V_C = −5.5	

TYPICAL APPLICATIONS

FAST-RECOVERY AMPLIFIER—observe small signals riding with large gates.

MODULATION MONITOR—measure amplitude modulation on a digital train pulse.

HIGH-AMPLITUDE HUM REJECTION—reject up to 200 volts peak-to-peak common-mode hum.

SEMICONDUCTOR CHARACTERISTICS—measure Zener diode ac impedance and Zener voltage together, measure transistor output impedance.

PULSE-HEIGHT ANALYSIS—select any pulse above a preset dc level.

COMPONENT MATCHING—check components to easily-interpreted tolerances.

MAIN CHARACTERISTICS

3 Modes of Operation—as a conventional preamplifier, as a differential-input preamplifier, or as a calibrated differential comparator.

50-mv/cm Sensitivity—nine calibrated attenuation steps to 25 v/cm.

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±100-volt Dynamic Range—permits common-mode signals up to 100 volts to be applied to the unit without attenuation.

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Comparison Voltage Accuracy—within 0.25% on the ±1-volt scale; within 0.20% on the ±10-volt scale; within 0.15% on the ±100-volt scale.

Safety Feature—the Type Z eliminates "floating oscilloscope" operation.

AC and DC VTVM—extends oscilloscope accuracy in both ac and dc voltage measurements to 0.2%.

Price, Type Z Plug-in Unit, f.o.b. factory **$525**

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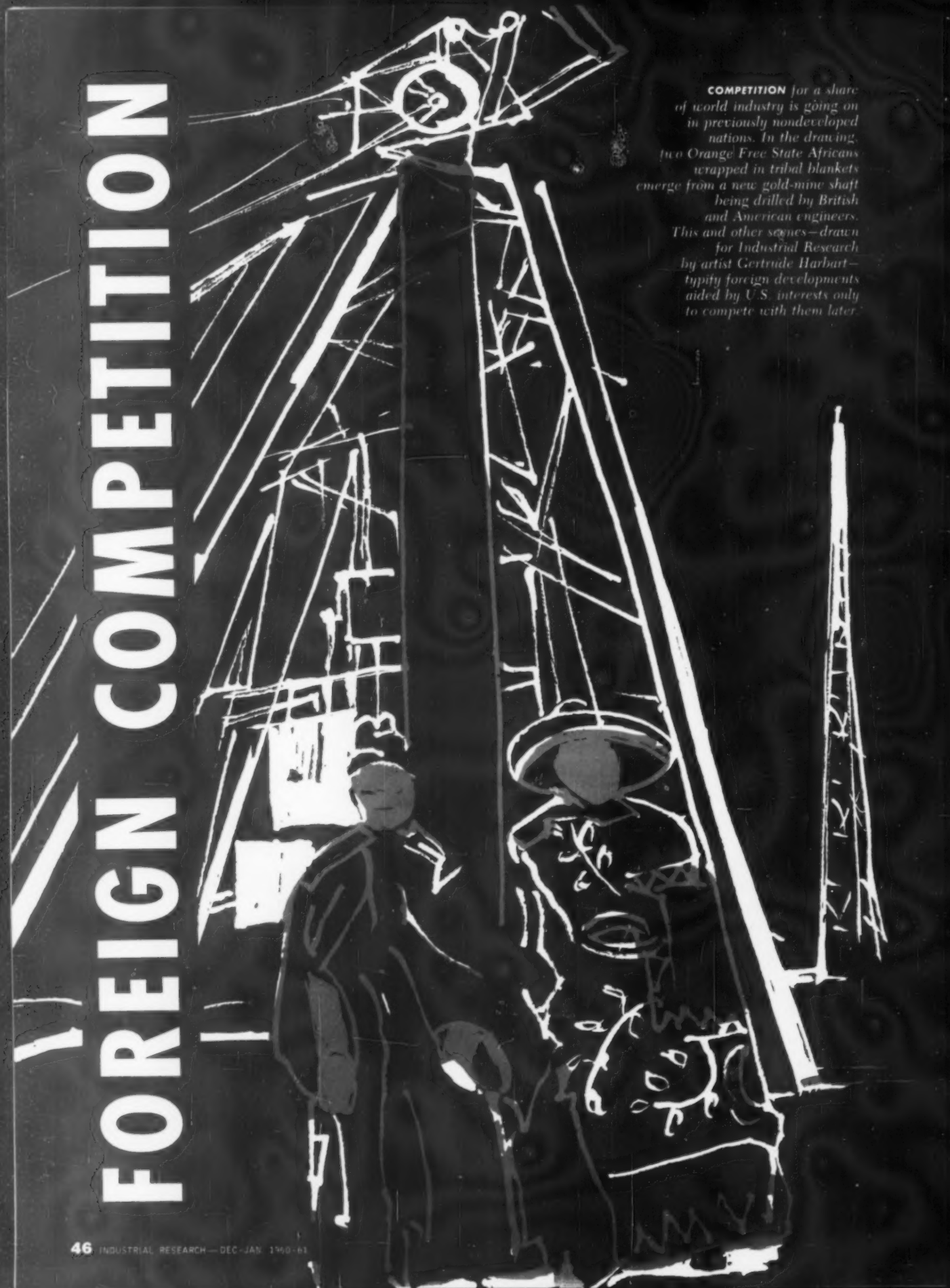
GENERAL ELECTRIC

CPA36 (10-60)

FOREIGN COMPETITION



COMPETITION *for a share of world industry is going on in previously nondeveloped nations. In the drawing, two Orange Free State Africans wrapped in tribal blankets emerge from a new gold-mine shaft being drilled by British and American engineers. This and other scenes—drawn for Industrial Research by artist Gertrude Harbart—typify foreign developments aided by U.S. interests only to compete with them later.*

by **A. M. Schwieger,** *manager of European technical observation, Armour Research Foundation*

Europe's new industry: threat or promise?

AN EX-GI RETURNING TO EUROPE after 15 years has to rediscover this continent anew. The changes he observes are not limited to the absence or abundance of food. They are much more profound, and in many respects amount to acceptance of a new way of life by millions of Europeans. Gone are the shortages of power, shortages of necessities, absence of luxuries. Economics of plenty are establishing themselves throughout Western Europe, resting solidly on the growing purchasing power of the populations.

Shortages are gone, but gone with them is the uncritical acceptance of American superiority in industrial achievement, born out of years of hardship, physical vulnerability, and widespread destruction. That now-defunct belief perhaps was cherished by Europeans as a vision of their material aspirations. Few among them would admit to that; yet many, if not all, worked hard to destroy it.

That Europeans have succeeded in their task is beyond doubt. Western Europe today hums with activity, jams its traffic, pollutes and polices the pollution of its air, consumes luxuries, and constructs dwellings all at rates comparable to the United States. Heavy industries enjoy unprecedented backlogs of orders. The only significant shortage is of manpower.

The sorcerer's apprentice

Western Europe is proud of its achievements, conscious of its economic power, but somewhat puzzled by it. Europe is in a quandary as to the next step—aware of world-wide economic and political implications of its every move. Yet it is virtually certain, should its economy continue growing at the present rate and barring short-term fluctuations, that it will pose an increasing threat to the United States economy: in a way, a modern version of the sorcerer's apprentice.

For the sake of a complete picture, remember that Europe is not embarking on new paths. Rather it is rediscovering them, restating old claims. These claims are based on nothing less than virtual domination of the world economy prior to WW II.

The forties and fifties made us forget that the quality of English and German industrial equipment used to be a byword, that the German chemical industry was to the world what American industry is now, that Europe's economy before the last war was as articulate as ours by the standards of the day.

One of our greatest achievements, mastery of nuclear forces, was based on fundamental concepts devised by Italian, German, Hungarian, and Danish brains, not to mention perhaps equal contributions of many other nationalities. While it is certain that applied research in a modern sense, mass industrialization, and industrial rationalization by resorting to well-systematized concepts are American inventions, few would question that lone-wolf research was born and thrived first in Europe, the pay-off being pre-war European industrial might.

The chemical industry, because it played a fundamental role in 20th-century progress, constitutes the most telling example of the varying fortunes of Europe. To better understand the question, let us travel a bit back in time.

An advantage of chronic shortage

Shortages of raw materials, which became significant at the end of the last century, acted then as powerful stimuli to development of substitutes and of intermediates necessary for their manufacture. Dyes, which up to the second part of the 19th century were imported exclusively from distant countries, were synthesized for the first time.

Dye manufacture (of indigo and alizarin) required chlorine, ethylene, and phthalic and sulfuric acids. Consequently, in the beginning of our century, intensive activities lead to development and semi-industrialization of such techniques as electrolysis of salt, liquefaction of chlorine, dehydration of alcohol, and catalytic oxidation of naphthalene and of sulfur dioxide. The approaching World War I and resulting demand for materials used in explosives manufacture promoted immediate interest in, and led to, development of the synthesis of ammonia.

Problems related to industrialization of ammonia processes were enormous. Corrosion, structural issues involved in high-pressure operations up to 3,000 psi (in the absence of quality steels), and lack of experience in heat transfer all had to be coped with rapidly. Concepts now dear to the chemical engineer—unit operations, applied thermodynamics, kinetics—were to emerge out of this period.

In a certain sense, the first 15 years of this century meant to Europe what the forties meant to the United States. Industries then grew capable of

major technological achievements, relying on the ingenuity of individual researchers and on the exceptional abilities of a few who could project laboratory curiosities to industrial operations.

Emancipation from scale-up techniques

These years also brought a realization that to reach maturity the chemical industry needed large concentrations of new methods—an emancipation from techniques of scale-up, where laboratory-size test tubes expanded full-scale merely to test tubes in the form of large-batch containers.

The twenties saw the creation of the I. G. Farben and French cartels as some of the examples of the newer concentrations of industrial might. (The scale-up revolution lasted much longer, and only now is nearing its well-deserved end.)

The new industrial giants quickly faced additional problems. Emergence of the automobile as a popular means of transportation and the growing demand for petroleum and its products were becoming painful realities to some European countries lacking natural resources or foreign exchange for purchasing abroad.

Shortages of raw materials at the same time lead to further development of chemical technology in the form of plastics and synthetic fuels. In the latter case, hydrogenation of coal seemed to be the answer. Based partly on the experiences of ammonia synthesis, this method of manufacturing fuels gained extreme importance for Germany during WW II, when 3.5-million tons of synthetic fuel came annually from this source.

World leaders at the approach of war

WW II saw the European chemical industry leading the world. A comparison of chemical exports from 1935 to 1938 shows that U.S. efforts amounted to little more than those of England taken alone. As an example, U.S. fertilizer exports of this period were matched rather easily by France. It is important to remember that in neither instance did the export figures exceed 20% of respective European totals.

While it is difficult to establish actual destinations of commodities exported in that period, probably only about a third of them left Europe. Making allowance for the somewhat integrated nature of the European economy and for a similar situation on the North American continent (U. S. exports to Canada corresponded to 15% of the total), it may be concluded that Europe's overseas exports in that period were roughly twice as large as the overseas exports of the United States.

The first years of war meant accelerated production throughout Western Europe. But by 1943 the intensity of the air attacks became a major factor diminishing industrial production, and about a year later the industrial effort of Western Europe was reduced to insignificant proportions.

Few if any direct data are available to cast adequate light on that period. An indirect example of prevailing conditions is offered by the specific figures related to production of detergents. Detergents appeared on world markets shortly before the war. Their importance to war economy may be judged from the fact that annual production was raised in Germany between 1939 and 1943 from 4,000 to 80,000 tons. In 1947 only 3,000 tons were produced in Germany, attesting to the thoroughness of destruction both of primary producing facilities and, conceivably, of raw-material sources.

PRODUCTION OF DETERGENTS (TONS)

	1939	1943	1947	1951	1955	1960
Germany	4,000	85,000	3,000	22,000	49,000	126,000
The rest of Western Europe	4,300	88,000	22,000	77,000	201,000	447,000
United States	9,000	50,000	100,000	314,000	470,000	691,000

Similar indications regarding slowdown of industrial production are given by the index of German production and by overall French and German figures. Based on German production of 1936 taken as 100, the index climbed during the war to an estimated peak value of 220; it was reported to amount to 63 in 1948. Inspection of data related to production of chemicals in France and Germany confirms that considerable time had to pass after the war before the various economies could recover fully.

(continued after photographs)

BRITISH TESTING *of auto "tyres" and wheels goes on in the extensive laboratories of Dunlop Rubber Co. Ltd.*

COBALT-60 SAMPLES *(above) are used at the Thornton Centre, Cheshire, England, to study effects of gamma rays on hydrocarbon oils. The research is being done to develop lubricants for atomic-power projects that can withstand action of high-energy nuclear particles and rays. At left, new types of belting fabrics are under research at Dunlop Rubber Co. Ltd.*

WEST GERMAN REFINERY *(below) to be completed this year by BP Benzin und Petroleum Co. at Dinslaken will decrease German petroleum imports measurably.*

PRODUCTION OF SELECTED CHEMICALS
(thousands of tons)

	1938		1943	1950		1960	
	France	Germany	Germany (France occupied)	France	Germany	France	Germany
Surfuric Acid	1270	2270	2540	1220	1450	1690	3210
Soda Ash	483	1050	1550	717	730	770	990
Chlorine	47	260	490	81	220	330	590
Methanol	7	80	240	14	70	40	280
Calcium Carbide	156	730	1520	176	630	300	1100

Unlimited demand, a hidden blessing

The end of the war left Europe not only the task of reconstructing destroyed industries, but also of transforming its war economy into peacetime standards. These tasks were complicated by a shortage of practically all commodities—a hardship that carried within it a hidden blessing in the form of seemingly unlimited demand.

The gradual increase of tensions between East and West, after virtually dividing Europe into two parts, rendered it mandatory for the U.S. to shore up the economies of the Western segment of Europe. The Marshall Plan, suspension of dismantling activities on the territory of Germany, compulsory and voluntary flows of visitors from the Western hemisphere all have injected funds for the rebuilding of European industry.

Since we are dealing with a series of politically separate economies, it is necessary to stress that despite the gradual unification of objectives the overall rate of recovery was by no means uniform.

Specific local conditions affected respective rates of growth. Five years after the war France still was engaged in major military activities in the Far East which sapped its ability to reconstruct the ravaged industry at home.

Holland, recovering from the serious loss of its overseas possessions, faced the prospect of reorganizing its traditional service-type economy to that of increased industrialization.

But Germany, starting with a relatively clean slate, could and did channel all its resources and foreign assistance to building modern, progressive industrial plants.

Not all European growth may be ascribed to the fever of reconstruction and development. Some of it, like the discovery of natural gas deposits in France, was the result of extended explorations and of good fortune. The abundance of a new source of energy, and recovery of sulfur contained in the gas, transformed France overnight from a traditional sulfur importer to a large sulfur exporter.

Similar occurrences throughout Europe, together with the growing abundance of capital, large-scale investments, and rapid programs of reconstruction, were broadening the purchasing power of the people. After satisfying their basic demands for food, housing, and clothing, Europeans saw their aspirations mount and their standards of living increase.

IF YOU CAN'T BEAT 'EM, JOIN 'EM

The trend is unmistakable. For the first time since World War II, and reversing the prevailing pattern of this century, Western Europe is selling about as much to the U.S. as it is buying.

The U.S. export boom is giving a shot in the arm to basic European industries such as steel and automobiles, and has a direct bearing on our gold reserve problems, with European hoarding of gold and dollars now almost double what it was in 1957.

While U.S. government aid started the cycle, American business which has everything cumulatively to lose is itself an ironic major supporter of foreign competition. Ford Motor Co.'s German subsidiary at Cologne reports its exports to the States jumped from about 3,000 cars in 1958 to almost 7,000 in 1960. In France, the 25% Chrysler-owned Simca auto firm shoved its U.S. shipments from 25,000 to about 60,000 for the same period.

Most other U.S. companies having subsidiaries across the Atlantic are increasing their exports to this country, though most are reluctant to discuss it. Remington Rand's shipments of portable typewriters from Holland, International Harvester's tractors from England, IBM's office equipment from its French plant are but a few of hundreds of examples of U.S. companies competing with themselves.

Our point is not that U.S. foreign-based industry is doing some dark evil in selling goods in their own country, but rather that "foreign competition" is a vast complexity. If nothing else, it shows that the economic destiny of the United States is inexorably interwoven with the economies of other countries — a truism that becomes clearer with every passing research development, production figure, and Volkswagen you pass in the streets of Kansas City. ■

As manager of Armour Research Foundation's European Technical Observation Group at The Hague, Netherlands, A. M. Schwieger directs the monitoring of technological developments in Europe on behalf of American industry. Schwieger was educated in Europe and in the U.S., holds several degrees in chemical engineering and chemistry from universities of both continents. As his job demands, he is fluent in French, German, and several Slavic languages.

Consumer industries notice the consumer

A subtle change then became apparent in the economy of Western Europe. For the first time the consumer-goods industries began to notice the consumer. Market-research studies and consumer-acceptance tests started making in-roads. Applied research designed to adapt products to the desires of public ceased to be looked down upon and was gaining converts. More than anything else, recognition of the consumer contributed to "Americanization" of the European way of thinking, and of growing.

Real growth, of course, was not possible with small political-market units. A definitive stimulus was afforded industry early in 1959 by creation of the two large marketing areas in Europe committed to reducing and eventual abolishing of internal customs and to setting up of common protective barriers.

Since the population of the European Economic Community, one of the two areas, is roughly 170-million, and since the "Outer-Seven" area counts a population of about 80-million with a distinct possibility for further expansion, it is obvious that the exceptionally large market which has been characteristic only of the American economy ceases to be unique within the areas of free economy.

It may be assumed that all advantages normally derived from such a large concentration of potential customers will be operative in Europe in the immediate future. That the common-market idea is rapidly gaining acceptance is obvious from the fact that the original schedule for abolishing internal tariffs between member countries already has been accelerated. This extraordinary step was taken only a year and a half after bringing the common market into existence!

Recent, partially common-market-caused progress in industrial growth is shown by chemical-production figures for West Germany. While in 1954 the combined chemical production of that country was six and a half times smaller than the corresponding U.S. effort, the figures for 1960 show this ratio reduced about five. All that while, the value of U.S. chemical production climbed from $19-billion to slightly less than $26-billion.

It is noteworthy that while Germany reduced the production gap by roughly 20%, the Soviet Union in this same period reduced the ratio of its chemical production to that of the U.S., from 2.76 to 2.52, or by about 9%.

CHEMICAL PRODUCTION BETWEEN 1954 AND 1960

	1954	1955	1956	1957	1958	1960
U.S. millions of dollars	6.49	6.35	6.2	5.72	5.4	5.30
Ratio of U.S. production to German production	2.76	2.97	2.99	2.86	2.49	2.58
Ratio of U.S. production to USSR production	2.35	2.14	2.07	2.0	2.17	2.09

Current per-capita gross national product in the U.S. amounts to about $2,800. The corresponding figure for Western Europe is about $1,000. To assess the comparison between the two figures realistically, an allowance must be made for the somewhat lower cost of living in Europe. A reasonable comparison of gross national products would indicate that Europe produces goods and services at about half the U.S. rate.

Despite that, a considerable proportion of European goods find their way to export. Inspection of the overall chemical export figures for 1959 shows that in that year, for the first time since the thirties, Europe's overseas exports exceeded those of the U.S.

EXPORTS OF CHEMICALS IN 1959
(millions of U.S. dollars)

United States (to all the world except Canada)	331.0
England	105.0
Germany	112.5
France (to all the world except Europe)	37.0
Italy	26.0
Belgium	27.5
Holland	31.0
Total of European countries above	338.0

Growing competition

Having expanded at a prodigious rate, it may be assumed that the European industry will have to slow down to consolidate its position. It is certain however that its new role cannot remain without dangers to the U.S. economy.

The European labor cost and salary structure constitutes a major long-range advantage. While it is estimated that the cost of research in Europe varies from 60 to 75% of the U.S. figures, it is doubtful if costs of development are effectively lower than in the States.

However, with growing standardization and abundance of local equipment, it may be assumed that development costs should head downwards in the future. The same generalization holds true for capital investments and operating costs exclusive of labor. While labor in Europe is just as eager for financial advancement as its U.S. counterpart, the gap between the two probably will remain appreciable for a long time.

In the past, the European industrialist traditionally expected high returns on investment, thus offsetting advantages of lower labor costs. Today that philosophy slowly is being replaced by the belief that lowered margins and increased production have much more to offer.

Strong motivation to improve productivity, resorting to increasing amounts of automation, also will be instrumental in making European goods more attractive. Depending upon how fast the continent expands, in the not too distant future we well might become concerned with the problem of coexistence with Western Europe. ■

by **T. F. Olt,** *vice-president, research and technology, Armco Steel Corp.*

the contest in steel

YOU MIGHT LOGICALLY ASK why most of the new steelmaking processes have been developed in foreign countries.

The answer to this is largely due to the fact that production units can be relatively small in foreign countries without severe penalties in added labor cost, whereas in the U.S. the high labor cost associated with small-scale production precludes the effective utilization of such equipment, and consequently new process development is much more speculative.

Raw materials and labor represent a high proportion of the cost of manufacture. It is difficult to make a good comparison of raw material costs, but labor rates can be compared quite simply. Average hourly steelworker earnings in the U.S. are more than $3. In Western Europe and Russia hourly earnings are less than $1, and in Japan less than 50 cents.

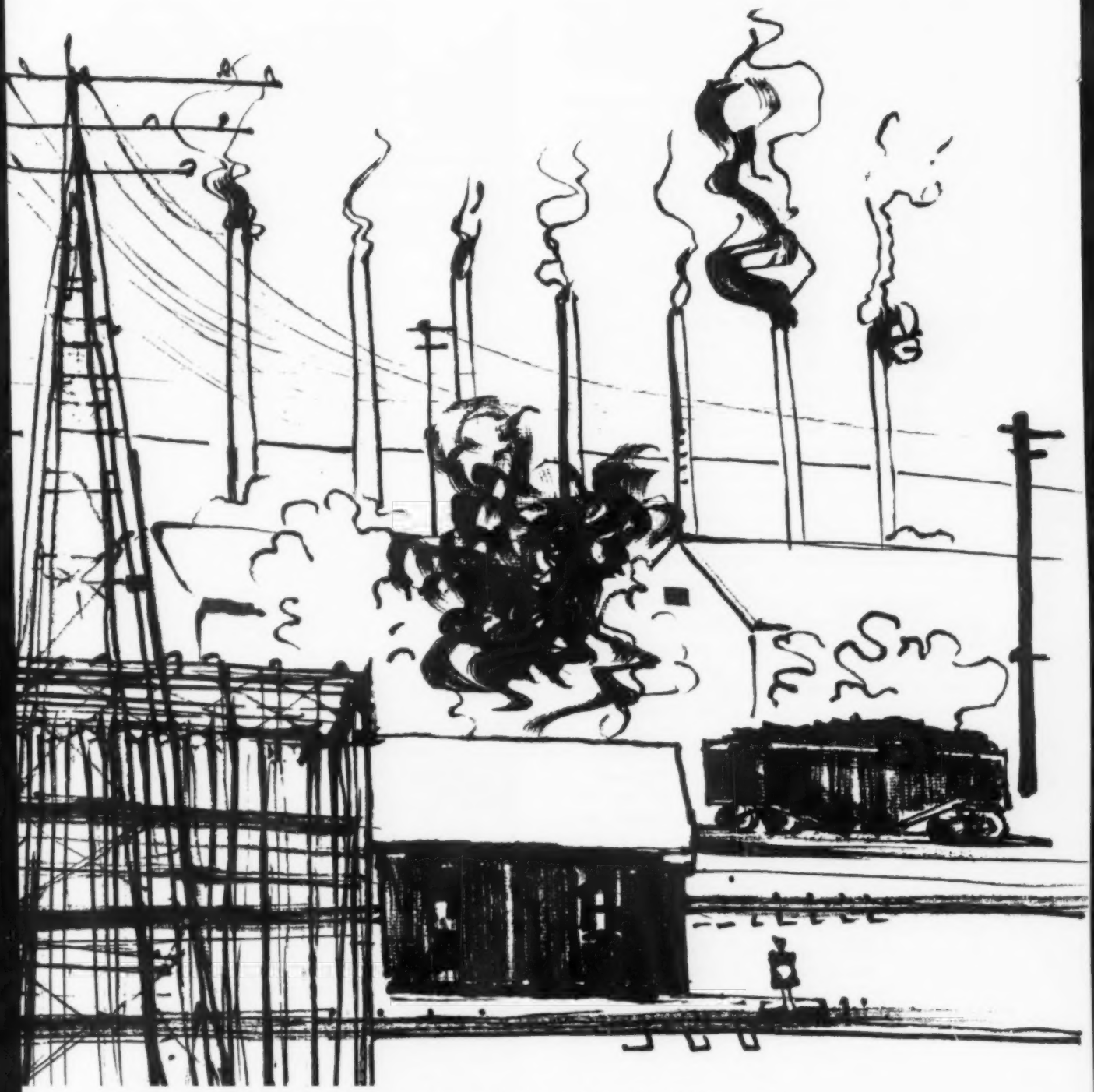
Are we pricing ourselves out of the market?

With foreign labor costing only one-third to one-seventh as much as in the United States, it is rather evident that competition on a purely price basis is not easy. U.S. industrialists are finding this particularly true in certain products being sold next to their domestic plant locations at prices approximating their own bare manufacturing costs.

Such competition has forced us to expand our research effort in studies directed towards the reduction in manpower utilization in the manufacturing operations (increased productivity) and also in projects designed to result in decreased investment cost per ton of product output.

Another phase receiving a great deal of attention in research is in the development of more sophisticated products designed to effect savings for our customers. When such products are patentable, they also serve as a basis for a licensing program and securing at least some income when used in foreign countries.

U.S. national policy has been to encourage foreign trade. Tariffs on steel products have been so nominal that even a 100% increase would not ma-



THE SOUND OF EUROPE'S STEEL INDUSTRY *once again is heard throughout the world—especially in Pittsburgh—as more and more foreign plants are being built. The advent of tonnage oxygen, a German development, has led numerous European nations to investigate steelmaking based on oxygen injection for refining. Air-pollution prevention, modern equipment, and higher wages are being introduced American style. At the same time, however, foreign industrial labor still costs only one-third to one-seventh as much as in the United States, and competition on a purely price basis is virtually impossible. Author Olt suggests American industry can compete now only through technical projects aimed at decreasing investment costs per ton of product output, devising entirely new types of steel, and by finding new applications and markets.*

terially affect our merchandizing problems resulting from rising imports of steel products such as reinforcing bars, farm fence, barbed wire, nails, and fasteners.

To make steel, it is first necessary to get iron. Between 50 and 55% of the iron units required for steelmaking are obtained by smelting iron ore with coke in a blast furnace which produces "hot metal," a molten iron saturated with carbon. This is charged into a steelmaking furnace along with scrap and fluxes, and refined by selective oxidation and desulfurization to a desired chemical composition. Only 23 of the 82 steel ingot producers operate blast furnaces to supply their own "hot metal."

Materials handling: huge job in steelmaking

More than two and a half tons of raw materials are required to make one ton of ingot steel. The diagram at right gives a rough breakdown of these raw materials. When two and a half is multiplied by 147.6-million (the U.S. steelmaking capacity), the magnitude of the ore-transportation and handling task may be appreciated. And this does not include the air and water used, which amount to 2.1 and 80 tons respectively for each ingot ton.

Most of the basic steelmaking processes employ pig iron, or "hot metal," as the major source of iron to be converted into steel. The coke blast furnace for ironmaking has been highly developed over a great many years and considerable numbers of improvements have been incorporated in operating procedures.

Recent improvements in raw materials have been in beneficiation. In the case of ore this means the increase in the iron-to-silica ratio; in the case of coal, the removal of slate and other objectionable components.

The form of the raw material also has been improved by sizing and agglomerating the fines. Agglomeration might be by sintering or by pelletizing. Either procedure provides a charge in the blast furnace which can be blown harder resulting in increased production.

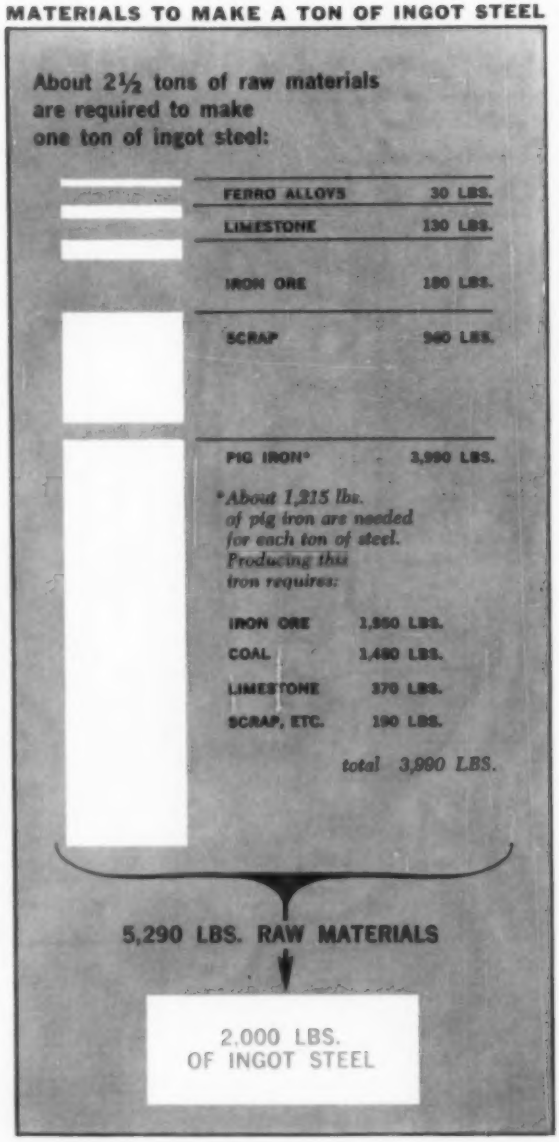
Another operating procedure that has resulted in increased production is the use of high top pressure, which allows more wind to be blown without increasing the velocity of the gas through the charge. Another is the use of steam for combustion of coke in conjunction with oxygen enrichment, or the use of additional blast temperature to maintain thermal balance.

One possibility receiving major attention involves the use of coke-oven, or natural-gas injection, in conjunction with either oxygen enrichment or additional blast heat. Such a procedure not only would increase the driving rate but also would decrease the quantity of coke needed.

Various nationalities have participated in these developments in ironmaking. In general the motivation for beneficiation and agglomeration of ores initially took place to a considerable extent in Europe. Poorer and more expensive raw materials forced research in these areas, particularly by the Germans and Russians, although the problems are general to most continental ores.

U.S. industry has benefited materially from these researches and also has expanded the fields of application greatly. Agglomeration by pelletizing for producing blast furnace feed was developed at the University of Minnesota Mines Experiment Station in conjunction with recovery of iron from magnetic taconite rock. The concentrate from the taconite rock was so fine (80%—325 mesh) that it could not be sintered economically on existing equipment. Interest in pelletizing now is expanding in Europe.

MATERIALS TO MAKE A TON OF INGOT STEEL


About 2½ tons of raw materials are required to make one ton of ingot steel:
FERRO ALLOYS 30 LBS.
LIMESTONE 130 LBS.
IRON ORE 180 LBS.
SCRAP 960 LBS.
PIG IRON* 3,990 LBS.
*About 1,315 lbs. of pig iron are needed for each ton of steel. Producing this iron requires:
IRON ORE 2,950 LBS.
COAL 1,480 LBS.
LIMESTONE 370 LBS.
SCRAP, ETC. 190 LBS.
total 3,990 LBS.
5,290 LBS. RAW MATERIALS
2,000 LBS. OF INGOT STEEL

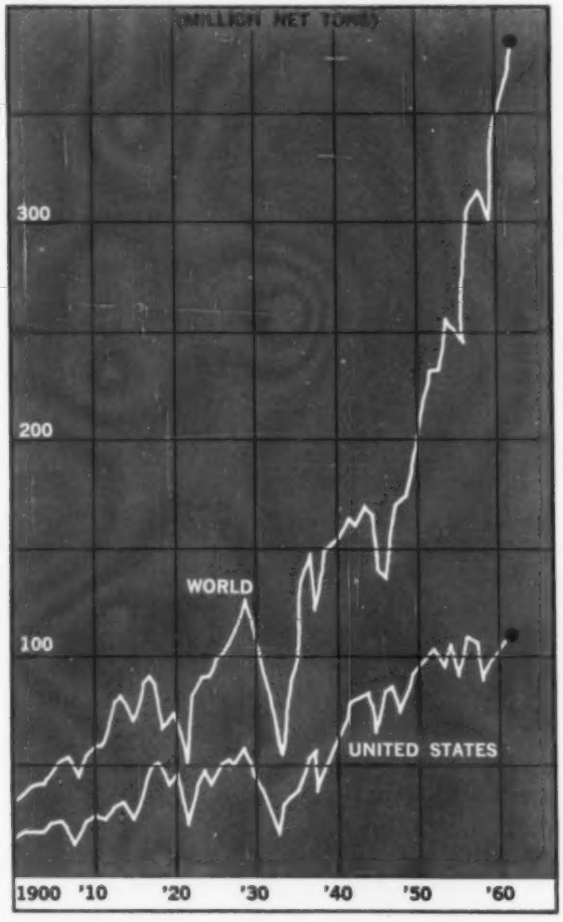
World steel capacity unprecedented

Both the highly industrialized countries and those bent on achieving industrial maturity have been building new steel capacity at a rate historically unprecedented. World steel production has more than doubled in the postwar period, rising from 150-million in 1947 to an annual rate of about 375-million net tons today.

During this interval, output in the United States, the world's largest single producer, has increased by about only one-third, whereas increases in other countries and especially in the USSR have been much more rapid. The diagram below shows the change in world and U.S. steel ingot production.

The steel industry often has been criticized as being slow to adopt new ideas, particularly in regard to manufacturing methods. Some of this criticism has been political, but it is true that changes in iron and steelmaking practices are mostly evolutionary in character. The reason is that investment cost is so high. Furthermore most of the operations are so efficient that it is often difficult to justify major additional capital investment unless corresponding gains can be attained. Development in recent years has improved productivity of existing equipment.

STEEL INGOT PRODUCTION OF WORLD AND U.S.



Tonnage oxygen permits new processes

The Bessemer and open-hearth steelmaking processes orginated in Europe in the latter part of the 19th century. Early in the 20th century the electric-furnace process of steelmaking was invented in France and these steelmaking processes have been developed very highly since then.

With the advent of improved cycles for the more economic manufacture of tonnage oxygen (a German development), the steel industry now is investigating new steelmaking processes based on the use of oxygen injection for refining.

Such new processes, developed in Austria, Sweden, Belgium-Luxemburg, France, England, and Germany, all have one thing in common: they employ gaseous oxygen for the elimination of metalloids. Some use high-pressure oxygen, others low. Some include lime injection in the oxygen stream. All result in greatly increased production rates as compared to open-hearth and electric-furnace refining. All are of foreign origin.

In addition, the Belgians have developed modifications in Bessemer blowing employing a combination of oxygen and steam or oxygen and carbon dioxide so proportioned as to produce the same thermal effect as when blowing with air. The product quality, however, is improved greatly in that nitrogen pickup ordinarily experienced in air blowing is eliminated.

Now in the shaping end of the business, the situation is just the reverse. Many of the major developments in rolling-mill equipment are of U.S. origin. Probably one of the best examples of this is the wide strip mill for rolling sheets. Many of these mills of American design (if not of manufacture) have been installed in most European countries as well as in Brazil, India, Australia, South Africa, Japan, and the USSR.

There has not been as much motivation for equipment development abroad as in the United States—again because other nations are not penalized so severely by high labor costs and low productivity as we are. Nevertheless, they are quick to adopt our improved equipment developments.

Steel competition, product by product

The steel industry makes a variety of products ranging from needles and pins to rails and H beams. The product mix varies from country to country. In a country like the U.S. the so-called "light steels" are produced in largest quantities, whereas in areas like Russia where industry is expanding rapidly, heavy steels such as rails, structurals, and plates predominate. Light steels are used exten-

sively in consumer durables, containers, and other areas associated with high living standards.

It may be noted that our exports are largely in sheet and strip, plates, pipe, tubing, and tin-mill products. Alternately, imports are largely such commodities as reinforcing bars, rods, wire, and wire products such as barbed wire, nails, and staples.

Also of interest is the trend in imports and exports over the last several years shown below. In December 1958, the U.S. passed from an exporter to an importer on balance. In 1959, U.S. imports totaled more than two and a half times the imports for 1958. Strike-caused *imports of steel-mill products exceeded exports by more than 190% in 1959!* This represents a shift of nearly 4-million annual tons of steel product, which is equivalent to a loss of jobs for 30,000 steel workers.

The situation for 1960 improved somewhat. By the end of August, imports had exceeded exports by only about 20%, largely because of increased exports of flat-rolled products to satisfy a high European demand.

U. S. FOREIGN TRADE IN STEEL MILL PRODUCTS IN NET TONS

	1959	1958	1957	1956	1955
Industry Shipments	69,377,067	59,914,433	79,894,577	83,251,168	84,717,444
Imports	4,391,791	1,794,884	1,152,549	1,334,338	970,022
Exports	1,507,930	2,687,415	5,175,448	4,156,747	3,870,889
Total Supply	72,260,928	58,931,902	75,871,678	80,428,759	81,816,577
Ratios:					
Imports to Total Supply	6.1	2.9	1.5	1.7	1.2
Exports to Industry Shipments	2.2	4.5	6.5	5.0	4.6

Process research overseas vs. product research here

While foreign laboratories are very active in iron and steelmaking process research, most product R & D is done in the U.S. Electrical steel, tinplate, and stainless steel originally were created in England and Germany, but most subsequent product development in these grades has taken place in the United States.

Possibly this is associated with the competitive nature of research in the U.S. as compared to the cooperative method in Europe. While U.S. laboratories freely compete with each other, much of foreign steel-product research is carried out by industry organizations such as the British Iron & Steel Research Assn., the Institute de Recherches de la Siderurgie in France, and Centre National de Recherches Metallurgiques in Belgium, the Netherlands, and Luxemburg. These organizations all carry out cooperative research available to their entire membership. The Mechanobr Research Institute of USSR has extensive personnel and facilities and serves the largest steel company in the world.

Corporate, competitive, research effort now is increasing in Britain and Germany. United Steels and August Thyssen have new and impressive facilities.

Foreign aid equals foreign competition

The problems that we face in the steel industry parallel those being experienced in other industries subject to intense foreign price competition. Having provided sufficient foreign aid so that our competitors overseas are well equipped with the most modern equipment, we now face equally efficient producers with manpower costs considerably below ours.

We already have "costed" ourselves out of the foreign markets in most products we manufacture and are having increasing difficulty in competing with foreign products delivered in our own backyards.

While Russia is not exporting steel as yet, we can point to reports of a recent shipment of 2,400 tons of pig iron to this country from the Soviet Union. Shipped in via the St. Lawrence Seaway to Buffalo and Detroit, the Russian pig iron sold for $49.25 per ton, compared to the domestic price of about $66 a ton.

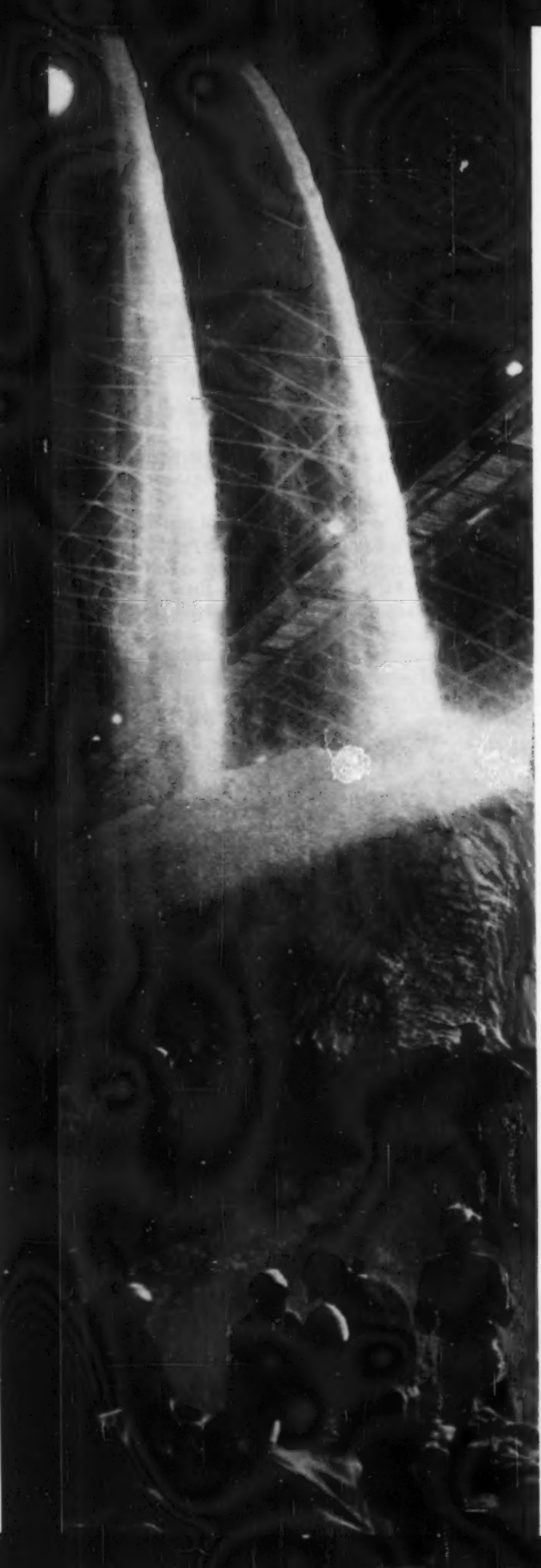
Russian production goals for 1959 to 1965 indicate that there may be much more of this kind of competition in steel as well as pig iron. The Soviet Union intends to invest more in the construction and reconstruction of iron and steel plants over the next seven years than in the past 30 years.

In 1965, production of pig iron will be raised to 65- to 70-million tons, or 64 to 77% more than in 1958.

Russian steel capacity will reach 95-million to 100-million tons by 1965, according to a recent study by our National Planning Assn., based on a 9% Russian industrial growth rate. If that happens the Soviets will possess an export capacity of considerable economic and political value.

The contest in steel may become the contest of survival. Overcoming our high cost disadvantages requires that industry eliminate any needless manufacturing expense or waste. We also need to expand our research effort in the direction of economizing on investment, reducing manufacturing costs, and developing improved products. ■

One of the more internationally minded of steel executives, T. F. Olt recently was named a member of the board of governors of the Building Research Inst., which is sponsored by the National Academy of Sciences and the National Research Council. A graduate chemical engineer (from the University of Cincinnati, 1928), Olt worked his way up at Armco Steel Corp. from a metallurgical assistant to vice-president of research and technology. He is currently vice-chairman of the general research committee of the American Iron and Steel Inst.



by **Robert W. Temple,** *research analyst, A. D. Little Inc.*

world rise of plastics

IN 1635, JUST 15 YEARS after the first Pilgrims landed in North America, a business for the manufacture of saltpeter and alum was established in Boston. Even with this early start, however, the chemical industry drowsed along for some 200 years until transportation advances freed its small manufacturers from the limitations of their strictly local markets.

Spotlighting the altered nature of industrial development in modern times is the story of plastics, child of the chemical industry and of the 20th century. Only 40 years ago an insignificant portion of its parent industry, plastics now shows an annual worldwide output of more than 5-million tons to support its classification as an industry in its own right.

It is a tribute to modern man's inventiveness in the use of new materials that this industry, which struggled through its infancy in the late thirties and early forties, in the last 20 years has grown 20 times in size and that plastics now have found application in every phase of our economy.

As the plastics industry has grown, so have individual enterprises throughout the world. The result is an industry highly competitive between products having similar end uses, between supplying companies, and between countries seeking a profitable trade balance. As the number of plastics and producers continues to increase, the industry can only become more competitive internationally.

Europe and Japan cut U. S. lead

The United States has dominated world production of plastics since World War II but, increasingly, its lead has been slipping. In 1952 this coun-

◀ **JAPANESE HAND LABOR,** *shown at the bottom of a cascade of ammonium sulphate, is the result of a lack of working capital following WW II, rather than lack of technical knowledge. Japanese scientists and industrial management today are regarded as among the world's finest, as witness the nation's change from importer to exporter of plastics. Japan today ranks fourth in plastics sales and consumption.*

try was responsible for 75% of world production. Recently, we have seen a marked increase in production both in Western Europe and Japan.

The U.S. controlled only about 40% of the world market last year as a result of rapid advances abroad. Between 1954 and now, the American plastics industry grew 50% but, during the same time, the plastics industries of Germany, England, and France increased an average 70%.

The U.S. still is the largest producer of plastic materials, and sells more than 2-million tons annually. Its nearest competitor, Germany, sells less than a third as much.

The table at right shows the sales of plastic materials for 1957 through 1960 (estimated where necessary) among the world's seven leading producers, which account for 90% of all production. The exact position of Russia and other communist countries has not been determined because only sketchy data are available. While a 1957 figure on plastics was reported by the Russian chemical industry, the Soviet definition of "plastic materials" varies significantly from those used in the rest of the world.

Continued growth in individual countries will be dependent upon the ability of producers to create new markets for plastics in each country and upon their competitiveness abroad. As exporters, the U.S. again is the leader. Yet, if our sales to other dollar areas (primarily Canada) are excluded, West Germany becomes the leading exporter.

SALES OF PLASTIC MATERIALS
(in metric tons)

Country	1957	1958	1959	1960
U.S.A.	1,932,000	2,050,000	2,489,000	2,730,000
Germany	546,500	628,600	805,000	900,000
United Kingdom	397,000	424,300	500,000	580,000
Japan	221,000	290,000	360,000	546,000
France	182,589	232,246	272,000	312,000
Italy	134,379	165,250	200,000	240,000
USSR	242,300			
World	4,000,000	4,500,000	5,400,000	6,300,000

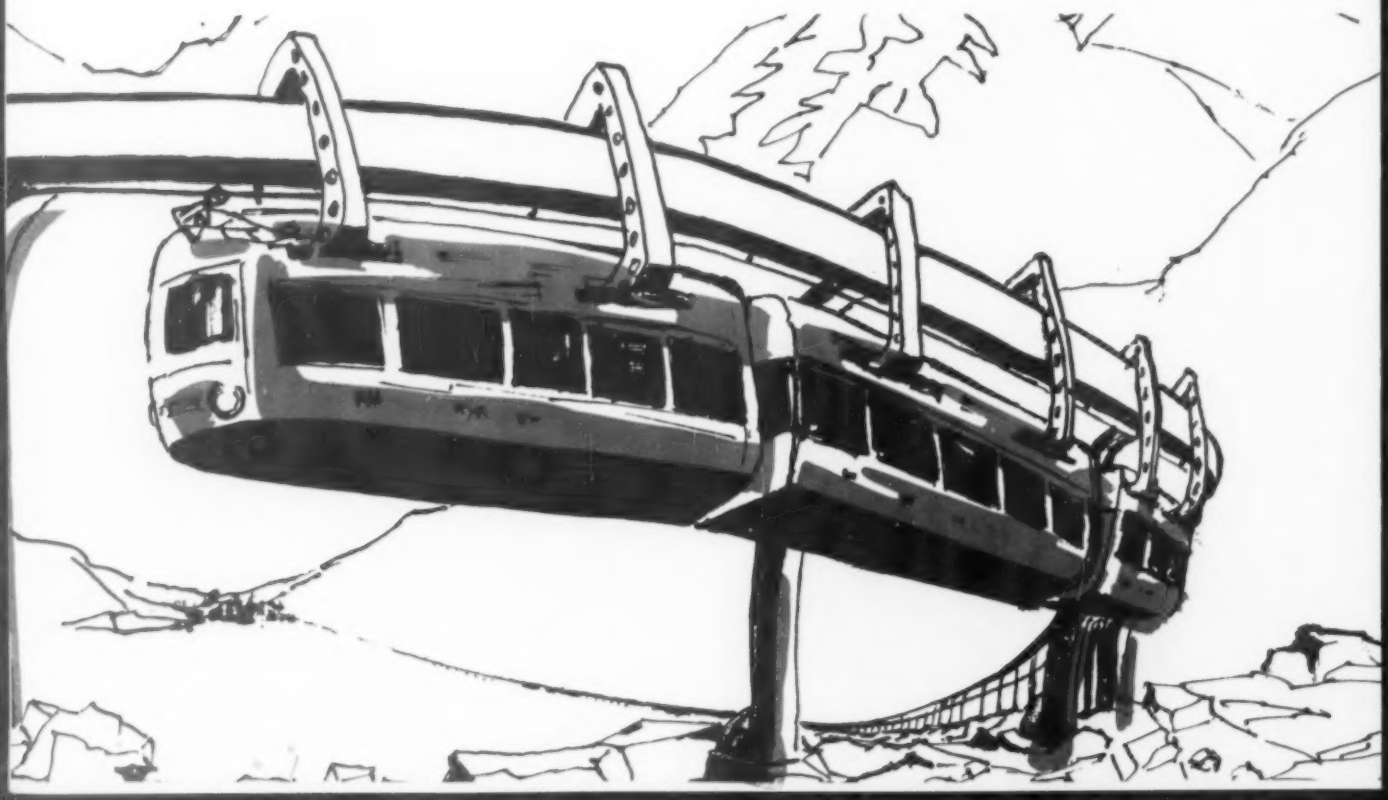
Imports: test of self sufficiency

While export figures are interesting, the imports of a country indicate the development of its plastics industry and its self sufficiency.

The U.S. shows a very small amount of plastic imports—in recent years less than a half percent of production. The biggest plastics importer is Germany, one of the biggest customers of the U.S. German imports form about 10% of its total domestic consumption.

England is the second largest importer, with foreign products also constituting more than 10% of its home market. Japan and France both had unfavorable balances of trade in the past, but with current expansion they rapidly are becoming net

The United States still is the largest producer of plastics, bu



exporters. All other major parts of the world are net importers of plastic materials and consume more than a half-million tons a year.

Another measure of growth in the plastics industry is consumption per person—the net balance of imports and exports added to total production and divided by population. Per-capita consumption indicates a relative level of a country's economy, industrial development, and availability of other raw materials (steel, aluminum, etc.).

PLASTICS CONSUMPTION BY COUNTRY
(in pounds per capita)

Nation	1956	1958	1960
United States	22	23.4	27.2
Germany	17	24.2	29.6
United Kingdom	10.8	14.1	17.4
Japan	4.1	7.2	11.0
France	7.8	13.0	16.5
Italy	4.2	7.2	11.0

As shown above, Germany is the leading consumer of plastics on a per-capita basis. Its consumption has increased 75% in the last four years to nearly 30 pounds per person in 1960. The United States, leader in 1956, has had a continual increase in per-capita consumption—but at a more modest rate—to more than 27 pounds.

Five plastics equal half of world production

The relative importance of individual plastics varies from country to country. Five of the largest plastics account for approximately half the world's production:

- *Polyvinyl chloride*, used in floor tile, garden hose, electrical wire coatings, and fabrics, is the oldest of large-volume thermoplastics and is made in almost all industrial nations. U.S. production represents 30% of the world total; France has planned the greatest increase (more than 40% between 1958 and 1961).
- *Polystyrene* has continued to show growth beyond expectation in household and packaging applications. The largest growth in 1960 in the United States, which produces 60% of world output, was in refrigerators. Germany is the second largest producer.
- *Polyethylene*, with applications in packaging, pipe coatings, construction sheeting, and many household articles, is both the most widely used of all plastics and the growth leader in the plastics industry. From 100-million pounds produced in the U.S. in 1953, sales in 1959 began to exceed a billion pounds, or about 63% of worldwide production. Top foreign producers are England (developer of high-pressure polyethylene), Japan, Germany (leader in basic research into low-pressure polyethylene), and Italy, in that order.
- *Aminoplasts* (ureas and melamine resins), used in textile treating and coating, synthetic fibers, plastic dishes, paints, and adhesives, grew about 35% in 1959 due to increased usage of melamines. Following the U.S. lead of 187,000 metric tons, is Japan with 82,700 tons, and England.
- *Phenolics*, for automobile and airplane parts, bottle caps, electrical apparatus, and plywood adhesives, showed relatively little growth until 1959 when it jumped 30% due to applications in the electrical industry. The U.S. produced about 292,000 tons in 1960, followed by Germany, England, and Japan.

In such a dynamic industry, these five plastics may form a considerably smaller percentage of production by 1970; newer materials, such as polypropylene and polycarbonates, could replace current leaders in the plastics industry.

Industry of giants and midgets

In the noncommunist countries, competition exists not only between nations but primarily between companies. Two major types of enterprises are involved in producing end-products from raw materials (hydrocarbons and other organic compounds): the chemical producer, which manufactures finished and semi-finished chemicals into powders, and the fabricator, which transforms these materials into goods for consumption. The two groups form an industry of giants and midgets.

The first group consists of a few large companies, while the second contains many small concerns. Fabricators outnumber chemical producers in all

Europe is gaining.

MONORAIL CARS, *the bodies of which are one of literally thousands of applications for plastics, are interesting in the context of foreign competition because, unlike origin of the automobile, all nations are considering monorail systems at the same time and development will be parallel. Monorails have been the most loudly hailed solution to the problems of public transportation in automobile-crowded cities, yet only a few have been built. Since 1950, six monorail demonstration systems have been constructed: two supported lines in Cologne, Germany; two suspended lines in Texas (of the type shown in the drawing); a supported line in Disneyland, modeled after the Cologne lines but with slower maximum speeds and poorer riding characteristics; and a short suspended line in Tokyo as an exhibition at the city zoo. A vast number of monorail systems have been proposed as economical transportation for crowded cities or in mountainous areas. Military applications also are suggested because of ease of installation, resistance to floods, and ease in dismantling. The largest present use of monorail principles, however, is in industry—for transfer bridges, turntables for heavy loads, and scales for weighing.*

Most basic developments in plastics occurred in Germany, France,

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producing countries by 10 or more. Chemical producers must make relatively large investments in facilities in comparison to fabricators, and this is perhaps the most important factor in minimizing the number of companies involved.

Also, because a product may rapidly become technologically obsolete, chemical producers must have financial resources to spend large sums in a short time. Fabricators must convert semifinished goods into usable consumer products; without them, chemical manufacturers would not have a market.

In the United States there are more than 200 chemical producers of plastic materials. Led by Du Pont, Union Carbide, Monsanto, and Dow, these chemical producers have annual sales of plastic materials of approximately $1.5-billion. The fabricators, numbering in excess of 5,000, have total sales of twice that.

Abroad, the production of plastics is more concentrated. In Germany, four companies account for more than half of production. England has one major and several smaller concerns accounting for the bulk of its production, and the same holds true for Italy. France and Japan have a larger number of concerns leading their efforts.

I. G. Farben offshoots in Germany

In Germany, splinter groups emerging from the I. G. Farben complex comprise most of the plastic producers. Farbenfabriken Bayer AG is Germany's largest manufacturer of plastics and supplies 20% of the market. It is the country's only manufacturer of cellulose plastics.

Other profitable plastic lines are the newly developed polyurethanes and polyisocyanates. Through subsidiaries, the company controls the sales of a large number of derivatives of ethylene, propylene, butylene, and butadiene.

Badische-Anilin-und-Soda-Fabrik AG (BASF) is the largest German producer of polyethylene. With current expansion it will have a capacity of 100,000 tons per year of high-pressure polyethylene and 12,000 tons of low-pressure polyethylene. BASF is the largest marketer of lacquer resins in Germany, and is active especially in polyesters and plastic dispersions.

Farwerke Hoechst AG controls its own petroleum cracking facilities, which supply essential raw materials, and has an olefin capacity of 70,000 tons per year. Hoechst was the first large-scale producer of low-pressure polyethylene and has been active with polyvinyl acetate, polyvinyl chloride, and polyesters.

Chemische Werke Huels is the 50% owner of a large synthetic rubber venture, including styrene and butadiene production. It has the greatest capacity for polyvinyl chloride in Germany, has facilities for polyethylene, and is going into the manufacture of polypropylene and co-polymers.

Growing subsidiaries in France

In France, the large number of subsidiaries and affiliated concerns make direct analysis more difficult, particularly since there has been a growing tendency for the larger companies to invest in newer developments through these minority-owned firms. This, however, has been helpful to France in minimizing working capital requirements and creating economical plant sizes.

Pechiney is France's largest producer of polyvinyl chloride and accounts for almost a third of the total tonnage. It represents 10% of the polyvinyl acetate production (which totals about 13,000 tons for the whole industry). The concern accounts for 35% of the polystyrene tonnage. Pechiney's share of the polyester market is relatively minor (about 5%).

Pechiney shares in the sale of polyolefins through its interests in three different subsidiaries. The first has production facilities of 5,000 tons per year of low-pressure polyethylene, and the other two have high-pressure polyethylene capacities in excess of 30,000 tons per year.

Rhone-Poulenc was a founder of the cellulosic plastics in France and is the largest in the field, with annual production of 8,400 tons. It also is the largest producer of polyvinyl acetate and accounts for about half of the country's capacity of 14,000 tons. The company makes 90% of the nylon plastics in France.

Other areas of activity include an approximate 15% share of the polyvinyl chloride market and a smaller share of polyesters. Silicones have been a major effort of Rhone-Poulenc, which is a licensee

and England; U.S. effort began with Baekeland's work on phenols.

of General Electric Co. in this area and accounts for half of the French market.

Saint Gobain, France's largest glass maker, also is a leader in the production of plastics. The company has the largest share of the $12-million glass-fiber market and makes a quarter of the total 8,000 tons of polyester produced annually. Saint Gobain has about this same percentage of the vinyl production. In addition, the company produces polyvinyl acetate, silicones, and fluorocarbon resins; through affiliates, it has interests in melamine and epoxy resins.

Kuhlmann accounts for another quarter of France's polyester resin production and has an active interest in polyvinyl chloride and polyethylene through its many affiliated companies. Air Liquid is in a similar position.

French chemical producers have at least 17 affiliates currently active in the manufacture of plastic material. The affiliates have been estimated to produce as much as $70-million worth of plastics out of a total of $210-million.

Britain's Imperial Chemical Industries

In England, the largest plastics producer—and by far the largest chemical enterprise—is Imperial Chemical Industries Ltd. One of the original producers of polyethylene some 20 years ago, ICI now has production facilities for almost 100,000 tons and still is expanding. It makes two-thirds of the country's total polyvinyl-chloride production and is the only large producer of polyesters; current annual capacity of 22,000 tons soon will be increased to more than 27,000 tons. ICI is a major producer of methacrylate, polystyrene, polytetrafluoroethylene, and other important plastics.

Shell Chemical Co. Ltd., which produces low-pressure polyethylene, polystyrene, phenolics, and epoxy resins, and The Distillers Co. Ltd., which produces polyvinyl chloride, polyethylene, phenolics, and vinyl alcohols, are the next largest in the plastics field.

English subsidiaries of Union Carbide and Monsanto are particularly important in polyolefins. They also supply a significant portion of the polyvinyl chloride, polystyrene, and phenolic plastic markets.

Montecatini Soc. Gen. has a position in Italy similar to that of ICI in England. Montecatini is responsible for about 60% of the country's total production of plastics, is in every major product line, and is a leading developer of the newer polyolefins. Montecatini's annual production of the polyolefins includes 5,000 tons of low-pressure polyethylene, 15,000 tons of high-pressure polyethylene, 20,000 tons of polypropylene (for which the company owns many of the basic patents), and 5,000 tons of polybutylene. Montecatini also produces phenolics, polyesters, polyvinyl chloride, and urea formaldehyde plastics.

The second largest Italian concern is Societa Edison, an electric utility which has diversified into chemicals. Either directly or through joint ventures with American companies, Edison produces polyethylene, polyvinyl chloride, polystyrene, acrylonitrile, and a number of plasticizers. Ozienda Nazionale Idrogenazine Combustibile (ANIC), the government-controlled chemical producer, is the third largest in polyolefins and vinyl chloride.

Japan's big three

Japan, like France, suffered from a lack of working capital following WW II, and, like Germany, it went through a vast decartelization. The chemical companies that emerged have been forced to form affiliations with other companies and to obtain additional funds from the government and technological assistance from abroad. While there are many companies producing plastics, sales of individual concerns are difficult to determine. "Trading companies" act as middlemen between most manufacturers and ultimate customers.

The three apparent leaders in Japan are:

- Mitsubishi Chemical Co., with 8,000 tons of annual polystyrene capacity and 11,000 tons of polyethylene capacity. It has entered into a joint venture with Monsanto to make 12,000 tons of styrene resin products, 2,400 tons of polyvinyl chloride, and a significant portion of the country's silicon production.
- Sumitomo Chemical Co., with 11,000 tons of low-pressure polyethylene capacity, 13,000 tons of high-pressure polyethylene capacity, and a smaller capacity for polyvinyl chloride.
- Mitsui Petrochemical Co. Ltd., which has a capacity for 11,000 tons of polyethylene, 10,000 tons of polyvinyl chloride, and 6,000 tons of phenolics.

Others, such as Japanese Geon (22,000-ton annual capacity in polyvinyl chloride), Toya Koatsu (leading producer of urea resins), and Showa Yuka and Furukawa (11,000 tons per year of polyethylene capacity each) are important in particular segments of plastic production.

The technology behind foreign growth

Past and future growth of foreign companies is partially based on their technological abilities and research facilities. The large growth of American

companies was due in part to U.S. technical advances during WW II, and to the freedom from war damage sustained by other leading countries.

The technology behind the growth of plastics can be broken down among: basic research into various polymers; process R&D for producing large quantities of the material: applications research to determine end uses of the plastic; and market research to tell how much can be sold and for what price.

Most basic developments in plastics have occurred in Europe. Polymers of styrene, cellulose acetate, vinyl chloride, and melamine were discovered in Germany a century ago. The French developed nitro cellulose at that time, and, more recently, rilson (a castor-oil based polyamide).

The English were innovators of high-pressure polyethylene and the polyesters. Recent advances by Germans include high-density, low-pressure polyethylene, polyurethanes, and polycarbonates. Italians were responsible for fundamental work in polypropylene and isostatic polymers.

Major developments in the U.S. started with Leo Baekeland's work with phenol-formaldehyde resins. In the last 30 years, U.S. basic research has produced the fluorinated plastics, silicone resins and plastics, and vinylidene chloride. Among the most promising new U.S. plastics is delrin (E. I. duPont), which is an acetal resin.

European versus American research

Although Europeans discovered most of the tonnage plastics, the U.S. has become the world's largest producer of plastics and the largest exporter of materials and technology. Continued American leadership is based on process technology plus highly developed applications and market research.

Research in America is expensive, according to several observers including Dr. A. T. Knoppers, president of Merck's international division. Research in Europe often is limited more to a certain specific area, thus is deeper and more creative. Others have observed that American applied-research techniques often can be combined profitably with the more fundamental and specific work of European scientists, thus making possible a high degree of cooperation.

Certainly, foreign firms realize that research, basic and applied, is vital to success. Europeans and Japanese have followed America's lead since 1950 in devoting from 4 to 5% of sales for research (excluding technical services, which are given on a limited scale only, and market research, which is only beginning).

For instance, in 1959 Japanese industrialists invested some $111-million in research, more than half of which went into chemical and electrical projects. This is more than double the research outlay they made in 1954.

One example is Toyo Rayon, which spent some $3-million in 1959 and close to $6-million in 1960, mostly on complex research in synthetic fibers and plastics. In 1954 the same company's development spending totaled only $700,000.

Toyo Rayon's 1,550 scientists and laboratory technicians (triple the number employed by the firm in 1954) have come up with two new fibers: pylen and toraylene, now in pilot-plant production. In the company's radiation laboratory, experiments are being conducted with graft polymerization (a process in which polyester fibers are subjected to gamma rays) in hopes of making the fibers wear better and resist water and grease more effectively.

(One problem in Japanese research is maintaining a continuing supply of scientists with graduate degrees, since industry has not yet furnished a real pay scale incentive. Starting salary for a PhD is only $5 a week higher than that of a four-year graduate.)

Foreign operations of U. S. firms

The growing market and competition abroad has led many major producers in the U.S. to open foreign operations. Such producers thus hedge against the loss of their own export business and offer an opportunity for more complete utilization of their own R&D programs.

Many U.S. firms, under licensing agreements, are marketing products developed abroad. For example:

- The polyolefin developments of the noted German and Italian scientists Ziegler and Natta are being commercialized by most U.S. plastics firms.
- Air Reduction Co. Inc. of New York has secured patent rights for vinylon plastic manufacture from the Japanese company, Kurashiki Rayon.
- W. R. Grace & Co.'s polymer chemicals division is working with a Swiss machine to make plastic container bottles from flat plastic sheets. According to Wolfgang A. Mack, the division's European research manager, this machine "does the job about 50% faster than current machines used for blowing plastics into bottle shapes."
- U.S. Rubber Co. will bring out a polyvinyl chloride conveyor belt for food processing operations that first was developed by England's National Coal Board as a fire-resistant belting for coal-mine use.
- A new synthetic resin, supposedly lighter than aluminum and stronger than steel, has been developed by a professor at Kyoto University, Japan. According to the professor, DuPont is negotiating for production rights.

Such sharing of foreign developments is, of course, highly beneficial to American industry. Yet, it supplies only a fraction of the answer to maintenance of U.S. supremacy in plastics. U.S. technology and economy have paced world plastics for 25 years, but foreign operations are growing at an unprecedented rate. Whether the United States can continue its leadership remains to be seen. ■

by **Rogers W. Johnson,** *business economist, General Electric Computer Dept.*

computer progress in Japan

A "CLEVER-IMITATORS" reputation, so frequently tacked onto Japanese industrialists by their American counterparts, has been contradicted by Japan's technical advances in electronics during the last few years.

Original contributions in computers and in such fields as microwave systems, power-line carrier systems, and electron microscopes have earned international respect for Japanese R & D, and have contributed to the nation's phenomenal ninefold electronics growth, from 1955 to 1960, to an annual volume of $1.2-billion.

Results of Japan's current emphasis on research can be illustrated by the fact that two of the most recent and promising developments in computers—tunnel diodes and parametrons—have come from Japanese scientists.

Esaki's tunnel diode

The tunnel diode, discovered just three years ago by Dr. Leo Esaki of Japan's Sony Corp., has become increasingly important as a potentially key device for solving major problems of computer development: boosting speed of calculation for industrial and business computers and reducing power and weight for aero-space applications.

Consisting of a p-n junction, the tunnel diode has an extremely narrow junction (about 100 angstroms). It originally was formed of highly doped (a relatively high amount of a controlled impurity) germanium. Later silicon was used.

Application of the tunnel diode to computers is being studied extensively because of the diode's high switching speed, wide environmental tolerance, basic simplicity, and adaptability to digital-computer circuits. Computers using Esaki diodes will be faster, smaller, use less power, and sell at a lower price than their conventional counterparts.

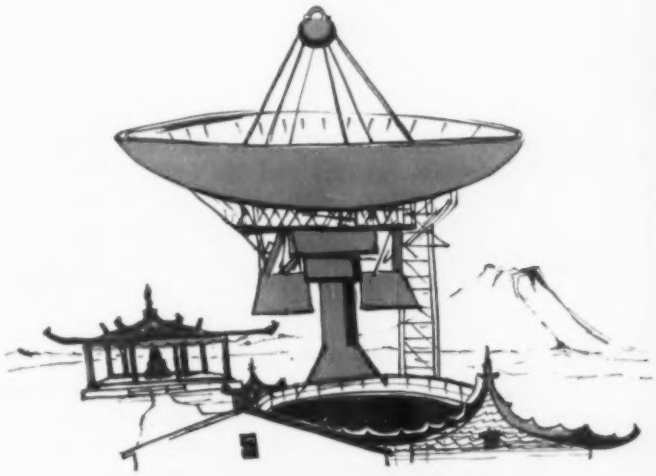
Encouraging experimental results have been obtained from high-speed random-access memories and dynamic logic systems utilizing multi-phase clock sources. Whereas logic circuit speeds for present-day computers generally are limited to a clock-rate range of one to 10 megacycles, use of tunnel diodes now can bring about clock rates as high as 30 mc. With further development, clock rates of 1,000 mc are expected to emerge from research laboratories.

In addition to computer applications, tunnel diodes will find uses in oscillators, amplifiers, amplifying detectors and mixers, limiters and switching elements, FM and television receivers, d-c to a-c converters, and equipment for satellites and space vehicles.

Developmental work now underway in Japan is directed toward producing tunnel diodes with uniform characteristics and, in computers, improving circuit and logic techniques. The goal is to overcome problems inherent in the use of the tunnel diode, such as the fact that it has only two terminals and that the obtainable voltage signal is quite small (less than one volt).

While computers using tunnel diodes are not yet on the market, the Electro Technical Laboratory (Japanese equivalent of the U.S. Bureau of Standards) is constructing a large high-speed computer similar to IBM's Stretch or Univac's Larc, incorporating an experimental supplementary tunnel-diode memory. Dr. Shigeru Takahashi, head of the laboratory, has revealed that addition times are planned to be about twice as fast as the Stretch computer's.

Also, the Tokyo University staff is developing a computer circuit using 35 Esaki tunnel diodes with 30-mc switching speeds. According to Takahashi, it is "theoretically feasible" to make a computer with switching capacity the same as that of the human



THE ELECTRONICS AGE *in Japan is symbolized by this satellite monitoring station. Two of the most promising electronic developments have come from Japanese scientists—the tunnel diode and parametron.*

brain by using 100,000 Esaki diodes, each with a 100-mc switching capacity. This will take a few years, however. Recently some technical difficulty has been experienced with the 30-mc Esaki diode computer program.

Goto's parametron

Another development, the parametron, invented in 1954 by Dr. Eiichi Goto, a Tokyo University physicist, also is undergoing continual refinement. Eight Japanese electronic manufacturers are developing parametron computers. (Several models now are on the market and are discussed later in this article.) These firms also are working on communication, control, and instrument equipment using parametrons.

The parametron consists of a simple electrical resonant circuit in which information is stored by controlling the phase of the signal.

Takahashi claims that a parametron computer can be built for about half the cost of a conventional vacuum-tube circuit computer. Other important advantages are that tolerances are less rigid, the possibility of failure is remote, and since there is no dissipating appreciable heat, no air-conditioning is required.

Although it generally has been believed in the United States that the parametron circuit requires uneconomical power consumption, Takahashi claims it consumes little power.

The main limitation of the parametron circuit is its slow speed, and this is the problem now being attacked by Japanese investigators. Tokyo University and TDK Electronics Co. are developing a magnetic thin-film parametron, claimed to be higher in speed, reliability, and stability than the presently used ferrite parametron.

The thin-film parametron has an excitation frequency of between 20 and 30 mc and a switching frequency (corresponding to clock frequency in non-parametron elements) of about 500 kilocycles.

This new parametron, basically a thin film alloy of iron and nickel high in magnetic permeability, can be produced at a substantially lower cost and more uniform quality than the ferrite type, and is believed to have considerably greater potential. TDK Electronics, which is now producing about 75,000 ferrite parametrons per month, expects to have the thin-film parametrons on the market early this year.

26 Japanese computers in 3 years

Reports are that a total of 26 computers have been designed, produced, and registered in Japan during the last three years. These include 10 known transistorized germanium diode and six parametron computers. The rate of development and production is increasing rapidly: 13 different models were produced during 1959, 50 in 1960, and 100 estimated for 1961. Most Japanese computers to date have been scientific systems. None has had large storage or extensive input and output facilities.

PHENOMENAL TELEVISION BOOM *witnessed in Japan in the past few years now is of 2.5-million-set proportions. Japanese companies can manufacture electronic equipment for two-thirds the cost of U.S. equivalent systems; progress in computers is unprecedented.*

Rogers W. Johnson, business economist at General Electric's Computer Dept., Phoenix, holds degrees in economics from Bowdoin College and in business administration from Boston University and Arizona State University. He has worked in technical marketing and computer development marketing at GE.

Computer developments have been accomplished by government and university laboratories and by computer manufacturers. The manufacturers, which are large electrical and electronic firms, include Toshiba, Hitachi, Nippon, Fuji, and Oki. In addition several smaller companies manufacture peripheral equipment.

Toshiba, the Tokyo Shibaura Electric Co., is one of the leading manufacturers of electrical machinery in Japan. Product divisions are heavy apparatus, lamps and tubes, telecommunications and electronics, electrical appliances, records, and automation and instruments. Toshiba has sales of about $260-million, operates 20 factories and two laboratories, and employs 30,000 people.

The company has announced both digital and analog computers and control systems.

Toshiba has technical agreements with several large U.S. electrical and electronic companies and is

part owner (with Remington Rand and a Japanese trading company) of a Japanese firm which has been set up to sell and service Univac computers.

The Hipac of Hitachi

Hitachi is another large electrical manufacturer in Japan, with sales of about $300-million, 20 factories, three laboratories, and 34,000 employes.

Principal computer made by the company, the Hipac 101 (*HI*tachi *P*arametron *A*utomatic *C*omputer), is a medium-size, stored-program, scientific computer using about 5,500 parametron logical elements. To supplement the low-clock frequency of the parametron, a parallel mode of operation is used providing comparatively high-speed operation. Sixty-two types of instructions are possible.

Nippon Electric Co., a manufacturer of electronic and communication equipment, TV and radio, does about $50-million in sales and has two factories. Neac 2201 is Nippon's original, small, paper-tape computer without magnetic tape or external memory. It uses a 200-kc clock pulse, has two index registers, and a 1.5 address system.

Neac 2203, an improved version of the 2201, incorporates magnetic tape and printing equipment, and consists of a serial decimal machine with fixed and floating-point arithmetic. The numerical word has 12 digit places, one word consisting of two sets of orders. This computer has 88 commands, a 1.5 address system, and three index registers. It is bilingual in that it operates both on alpha-numeric representations and on the Japanese phonetic alphabet, "katakana."

The internal magnetic-drum memory has a capacity of 2,040 words with a mean access time of three milliseconds. The external memory is 200 words of magnetic-core storage, up to 10,000 words of magnetic-drum storage, and up to 10 magnetic-tape units with a capacity of about 180,000 words.

Although this medium-size system (which was designed and built by a group of only 10 engineers), is claimed to be similar in size and function to the IBM 650, it sells for about half the price. Nippon is reported to have orders for more than a dozen of these computers.

Nippon's parametron

The Nippon parametron computer is a large, binary, digital computer called the M-1. The word length is 40 bits, core memory is 256 words, and the command structure has 126 to 150 instructions. Its 5,000 parametrons are supposed to reduce the cost of the machine to one-tenth the cost and one-third the power of a similar machine with vacuum tubes. Patents have been applied for in eight countries including the United States.

Fuji is the foremost Japanese communications manufacturer, with sales of about $20-million, three factories, and 5,000 employes. In 1956 the firm built the first Japanese electronic computer, Fujic, which is binary, has 32-bit word length, 225-word memory, and arithmetic speed of 1.6 ms. Fuji now is building five models, including one parametron, and also produces a tape perforator, photo-electric-tape reader, and card reader.

Oki Electric Co., a manufacturer of communications equipment, has built one parametron computer. Another Oki product, a high-speed printer capable of printing 18,000 letters per minute, is designed for use with the IBM 1401 in Japan. Oki also makes a model-58 photo-tape reader, which reads a five- to eight-track punched-paper tape at the rate of 12,000 or 24,000 characters per minute, with 120 or 180 characters per line spaced at 10 characters per inch.

Kokusai Denshin Denwa Co. has planned to market the first Reactron computer. The only information available now is that the computer has a high clock rate of 350 kc. Other known manufacturers of peripheral equipment include Shinko Seisakusho (printer) and Kurosawa (teletype equipment).

Tokyo University's computer research staff has completed two ferrite parametron computers for their own use. PC-1 employs 4,200 parametrons. PC-2, using 12,000 parametrons, 300 transistors and diodes, and 300 electron tubes in its main computing unit, operates at 340 usecs (microseconds) on 15 decimal digits. It has addition and subtraction speed of 40 usec for fixed point and 150 usec for floating point. The memory unit has a 4,096-word capacity with dual-frequency, magnetic-core matrices.

Remington Rand and IBM in Japan

Two U.S. firms are operating in Japan. Remington Rand and two Japanese companies (Toshiba and a trading company) have joint ownership of a firm which rents, sells, services, and later will manufacture Remington Rand equipment. Also, an IBM subsidiary has an assembly plant in Japan, and five Japanese computer manufacturers recently have entered into a license agreement with IBM under which all its computer patents will be made available to the manufacturers on a royalty basis.

The Ministry of Internal Trade & Industry underwrites the development of computers by an increasing amount each year—$650,000 for 1960. It also has requested a $6-million government appropriation to establish a unique semi-governmental electronic computer firm under joint capitalization with all computer manufacturing firms. The company, Nippon Denshi Keisanki Kabushiki Kaisha, would purchase and lease Japanese computers.

The firm, which probably will become a reality this year, is expected to enter into technical license agreements with non-Japanese producers and sublet these licenses to member firms. It also would engage in supplemental research and development, training, and especially computer programing.

A $40-million computer market

Japanese production of computers plus imports indicates that the nation's computer market last year was about $40-million. Japanese manufacturers to date have orders for about 50 computers in addition to the 26 already installed.

Because few Japanese can afford half-million-dollar computer rentals, the market for large systems is restricted.

Present users of Japanese computers are primarily the manufacturers' own engineering departments and laboratories, other laboratories (especially communications), the government, universities, and a few business and industrial firms. Companies producing the most units are Nippon, Toshiba, and Hitachi, in that order, and the total value of all computers manufactured by Japanese companies in 1960 was about $7-million.

Imports of computers to Japan have risen sharply in the last five years, from $200,000 in 1955 to more than $30-million last year. In all, some 75 computers have been installed by U.S. companies—IBM, Remington Rand, Burroughs, Bendix, and Royal McBee —and these companies currently have orders from Japanese customers for more than 100 additional machines. While the majority of the computers installed and ordered are small- to medium-size business systems, several large-system purchases have been made—by Yawata Iron & Steel, Fuji Iron & Steel, Nippon Kokan, and the Japanese Meteorological Agency.

Punch-card systems

Japan is a large user of punch-card systems. In 1950 there were 14 installations; today it is estimated that there are more than 500. Since Japan has some 1,400 companies with a capitalization of more than $300,000 and 160 companies at the over-$3-million level, the demand for and use of punch-card equipment will continue to be heavy.

Users, of course, are limited by what they can afford to pay. Justification of computers as labor replacers is less important in Japan than in the U.S., not only because of Japan's comparatively cheap labor, but also because of a traditional paternalistic relationship of Japanese employers to employes. Thus, many advanced applications of computers in Japan are only for computations which cannot be performed manually.

There is considerable potential for service-bureau operations in Japan. Japanese companies are accustomed to cooperating, and service bureaus would provide experienced programing and lower costs. The Japanese Electronic Industry Development Assn. has a large computer center which is half government and half privately owned, and the trade ministry is forming an even larger computer center.

Of the $40-million spent for computers in Japan during 1960, about 80% represents imports from the United States and the balance homemade machines. Japanese computer manufacture is expected to double each year through at least 1964. One estimate by a member of the trade ministry is that the Japanese is potentially 1/20th the U.S. market.

Land of computer promise

A consideration of Japan's economy and its computer manufacturing activities and market, reveals several conclusions about future Japanese progress:

- Japan, dominant industrial nation in the Far East, must import 90% of the raw materials it uses. Computers, and electronics generally, require a comparatively low consumption of raw materials and also are particularly well suited to Japanese labor skills. Electronics expansion, especially of computers, is the prime objective of the Japanese ministry.
- Japanese electronics is more advanced than that of most nations. Tunnel diodes and parametron computer elements are internationally interesting and promising.
- Since Japan has only one-tenth the computer R&D expenditure of the U.S. and currently is about five years behind the U.S. in general computer development and progress, there will be considerable technical licensing with U.S. computer firms.
- Japan's short supply of capital will influence computer activities such as amount of investment, research and development, leasing, delayed profits, etc. It also means that the Japanese government will play a significant role in computer activities.
- Japanese companies can manufacture computers for two-thirds the cost of equivalent U.S. systems. They probably will manufacture and export computer components first and then central processors before producing entire computer systems.
- Japan probably will supply the majority of its internal requirements in four years. At that time, the ministry possibly will prohibit the importation of non-unique computers.
- Not expected to be a significant exporter of computers for some five years, Japan will be handicapped in many markets by equipment and program compatibilities and in applying, leasing, and servicing computers off-shore. Probably initial exports will be to other Far East nations.
- U. S. companies will be able to supply much of the Japanese market for the next three years and will be sending some of their most advanced systems to Japan for many years.

Recognizing the growing importance of the electronics industry to the country's economy, the Japanese government recently established an inspection bureau to assure that no inferior electronic merchandise is exported. With this official emphasis on quality and with the government conducting research in its own laboratories and also subsidizing research and experimental manufacturing by private companies, Japanese electronics has come a long way from the "clever-imitators" label it may have deserved a decade ago. ■

I R

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SPEEDUP IN OFFICE COPYING

GLAMOUR GIRL FRIDAY of the office-equipment industry these days is the copy machine, fast growing to a leadership position in the field where it already accounts for more than $270-million in annual sales.

Copy machines get more and more attention as their manufacturers — now some two dozen — bring out new copying processes and streamlined desk-size copiers which are becoming more versatile with each new model. Modern copiers already have reached the push-button stage and soon will be copying everything but milady's new hat. Can you imagine an office staff having no need for carbon paper or tissue? With the new high-speed, low-cost copiers, that day practically is here.

Purchasers today have their pick of six basic copying processes, each with its individual merits and applications, and a selection of models that range from smaller than a typewriter to bigger than a desk, and from less than $100 to several thousand dollars each.

Yet, with all this product sophistication, the office-copying machine is still in its childhood as a business, for its present boom began just eight years ago. Its origin, curiously enough, was not in the United States, but in Europe.

While office copying is relatively new, there always has been a need and demand for it. In the past, there were two principal methods of copying. One was conventional two-step photography. It required darkroom and wet chemicals, and the operation generally was considered sloppy, time-consuming, and not suited to the office area. A spot in the shop or basement was far better. Nevertheless, quality of the copies often was good.

Paper-negative copying

The second method, an offshoot of the first, was the photocopying process; similar to ordinary photography, it used a paper negative. Daylight processing could be done automatically, but the process required huge machines which, like the darkroom, had no place in the office. The machines were costly, as were paper and other supplies, and consequently volume had to be large to justify the expenditure.

That was the status of office copying in the United States in 1952 when the diffusion-transfer process first made its appearance here.

Diffusion transfer was developed in Europe, and the first achievement was emergence of an acceptable diffusion-transfer paper. Two companies came up with it at about the same time: Agfa, of Leverkusen, West Germany, and Gaevert, of Antwerp, Belgium. Work was started in 1938 or 1939, but World War II relegated it to the sidelines.

When peace returned, research was resumed, and it became apparent that development of a new machine was needed to make the diffusion-transfer process practical.

Agfa moved first, gathering a group of wet-process equipment manufacturers to demonstrate to them under laboratory conditions how a copy could be made. In effect, Agfa challenged potential manufac-

turers to come up with a machine that would tick.

One of the men present, Dr. Walter Eisbein, picked up the gauntlet. He returned to demonstrate to the same group a machine that everyone agreed would get the diffusion-transfer process off the ground. This was in late 1947 and the process was put on the market, first in Germany, in 1949.

Lens-less diffusion transfer

In the diffusion-transfer process, light passes through a photographic-type negative to the document to be copied, and then is reflected back to the sensitized surface of the negative. Thus exposed, the negative is placed in contact with a sheet of chemically treated copy paper, the two are passed through a liquid developer, and then through rollers that remove the developer and press

PROCESS	TRADE NAMES	SPEED	COST OF MATERIALS (per letter-size copy)	ADVANTAGES AND LIMITATIONS
Diffusion-Transfer	Apeco and 16 others	First copy 30 seconds; second copy using same negative in 15 seconds.	First copy eight cents; second copy using same negative four cents.	Some models make only one copy from a negative; others make two or even three. Various weights and five colors of paper are available. Copies all types of originals, including colored ink and spirit duplication. Prints in black only.
Dye-Gelatin Transfer	Verifax	First copy 50 seconds; other copies using same negative 20 seconds each.	First copy nine cents; other copies using same negative a quarter-cent each.	A number of copies can be made from one negative. Copies can be made on inexpensive non-sensitized paper. Prints black on white only. Originals on some dark-colored paper stocks (such as blue) do not reproduce satisfactorily. Some colors of ink do not copy well. Operation less automatic than in other processes.
Thermography	Thermo-Fax	Four seconds.	Five cents.	Several colors and weights of paper available, including gummed sheets of labels. Accessories adapt process to many copying uses. Originals must be in carbon or metallic inks. Some ballpoint pen inks and some printed colors will not reproduce well. Uses no liquids.
Diazo	Bruning Copyflex Copymaker Ozalid *(used mainly for reproduction of engineering drawings — not for office copying)*	Continuous copy feeding — up to 300 letter-size pages per hour — larger models feed up to 75 feet per minute.	One cent or less.	Some models take printed matter or drawings up to 54 inches wide. Several colors of paper and printing are available, with five colors of printing on one page possible using manual application of solutions. Original must be one-sided and translucent. Copies have less contrast than in some other processes.
Electrostatics	Electro-Stat Xerox 914	Eight to 12 seconds.	One to three-and-a-half cents.	Newest process on the market. High-fidelity reproduction, with multiple copies of equal quality. Uses no liquids. Haloid-Xerox 914 rents for $95 a month, Apeco Electro-Stat for $40. Machines also may be purchased.
Facsimile	Alden Fairchild Hogan Laboratories Stromberg-Carlson Times Facsimile Western-Union	Thirty seconds.	Four-and-a-half cents.	May be used for long-distance communication since copy is made by photoelectric scanning of original. Can be used to prepare stencils. Some models will copy originals of any length. Can be used to copy only selected portions of original. Uses no liquids.

the two sheets together. When peeled apart, usually by hand, the treated paper is a copy of the original. No lens is used, and consequently copies cannot be larger or smaller than the original.

Eisbein's machine, for which he was granted a patent, was followed by others'. Later he received a patent in the U. S. as well as in other countries. The idea was spreading throughout the world, and the process at last reached America in 1952.

At this stage Eisbein ran into trouble. He had started a company known as Develop, in Germany, and hoped to get distribution in the United States. He was not successful. The big American office-copying manufacturers apparently were not interested in what he had to offer.

Exception in Remington Rand

The one notable exception was Remington Rand. It didn't help Eisbein, however, because Remington took on, not Eisbein's machine, but another made in Germany, named Lumoprint. Eisbein finally achieved U.S. distribution through an exclusive arrangement with the Copease Corp. of New York.

Copiers made an instant hit in the United States in 1952. Immediately, the public decided this is what it wanted: here was a way to make a copy without the necessity of a darkroom and trays full of liquids. Here, thought the executive, is something my secretary can do and originals won't have to leave the office.

Leader among U.S. manufacturers of diffusion-transfer machines is American Photocopy Equipment Co., which accounts for about 25% of sales of desk-top machines using this process. Apeco began marketing a two-piece, wet-process photocopy machine in 1939 and 13 years later brought out a small diffusion unit which was the first of the modern, easy-to-operate copiers. Still another Apeco advance, in 1958, was the introduction of the first diffusion office machine using a one-step process.

Today diffusion-transfer, earliest on the market, has more manufacturers than any of the other processes. Prominent trade-names, in addition to Apeco, include A. B. Dick Photocopier, Anken, Copease, Cormac, Constat, Contoura, Copy-Craft, Dri-Stat, Genco-Exact Fax, Heccowik, Instant Copier, Nord, Photorapid, Photocopy Duplicator, Quick Silver, and Remington Rand. Only two U.S. companies, Apeco and Anken, manufacture copy paper for use in diffusion copiers.

Akin to the diffusion-transfer process is the dye-gelatin transfer of Eastman Kodak Co. The company's widely distributed Verifax machine is a one-solution contact copier with which a number of single copies may be made from an exposed and developed matrix, corresponding to a photographic negative.

The emulsion on the matrix consists of silver halide, developer, and dye-forming components. After exposure, the matrix is inserted into an activator solution. Areas of the matrix which had been exposed to white light become hardened; the dark-image areas remain soft and may be partially transferred to untreated paper by squeegee contact with the matrix. Repeat transfers make additional satisfactory copies. As many as eight or nine copies can be made in this way, the number depending somewhat on the quality of the original and the operator.

3-M's thermography

While Kodak was advancing its Verifax copier, Minnesota Mining & Manufacturing was bringing out an entirely different concept, developed by Dr. Carl Miller of its research staff, and known as the heat-transfer or thermographic process.

Here, infrared rays pass through sensitized copypaper to the original document. Carbon or metallic particles of the printing on the original are heated. The hot image turns the copypaper dark.

There are some limitations to this process. Originals must be of infrared absorptive inks, such as carbon-based or metallic inks. Thus, some ballpoint-pen inks and some printed colors do not reproduce well. However, a number of manufacturers of printing inks and of ballpoint pens now have products on the market which give good results in thermographic copying.

Dry, versatile Thermo-Fax

Despite handicaps and early disappointments, 3-M now has a heat machine with such tremendous acceptance that it commands about 35% of the copy-machine market.

One reason for this, certainly, has been the fact that the Thermo-Fax Copying Machine was the first completely dry office copier and, for the small-volume user, it still is the least expensive of the processes which produce copies without use of liquid or vapor chemicals.

Perhaps another reason for Thermo-Fax's continuing popularity has been the company's emphasis on the versatility of its product. Thermo-Fax specializes, among other things, in providing a wide variety of printing papers—from airmail lightweight to colored bonds and gummed sheets of labels, the latter offering time-saving reproduction of small or, especially, infrequently used mailing lists.

Another development enables a low-cost projection transparency to be made from almost any document in seconds merely by running a special film with the original through a copying machine. The resulting transparency, for use on an overhead projector, may be made in positive, negative, or colored form. Still another development allows for automatic sealing of documents in plastic for protection.

Research to find new jobs for the Thermo-Fax copier is being carried on constantly, according to John R. Favorite, technical director of 3-M's duplicating products division, who sees a continuing development of Thermo-Fax's usefulness.

From blueprinting to diazo

On the fringes of the photographic, diffusion-transfer, dye-gelatin, and thermographic processes emerged a method of making copies the basic concept of which had long been used in the reproduction of engineering drawings. This was known as a blueprint machine, and it has been supplemented by a new process, also developed in Germany and known as diazo. Its best-known offshoot is Ozalid (which, with the addition of one consonant for euphony, is *diazo* spelled backward).

The advocates of diazo took a look at the office-copying field, and decided it was for them. They brought out smaller machines that today are recognized under such names as Bruning Copyflex and Copymaker.

While all this scurrying for markets was going on, a little-noted but parallel development was gathering momentum. This process, really physical or electrical photography, came into the market under the then-unfamiliar term xerography, the word being the brainchild of an Ohio State professor who crossed the Greek *xeros*, meaning "dry," with *graphein*, meaning "to write."

Xerography was discovered by Chester F. Carlson, a patent attorney with a printing background who was impressed with the difficulties of copying original material such as legal documents. All conventional printing methods—letterpress, offset, typing, photography—were expensive or time-consuming for a single copy. Moreover, reproduction generally necessitated the original document's leaving the office, a serious drawback with a confidential paper.

Carlson sought a safe, fast, inex-

pensive way to make photo-exact copies so that time spent in proofreading also could be eliminated. He felt the answer lay in the use of photoconductive insulating materials and the principles of static electricity.

An application of static

Carlson's theory bore fruit. In a darkened room he rubbed a sulphur-coated plate with a handkerchief to charge it frictionally with electricity. Then he placed a transparent ruler with black markings over the plate, and exposed both to light.

In about 10 seconds he turned off the light, carefully removed the ruler, sprinkled a little lycopodium powder on the plate, and gently blew away the residue. Then he turned on the light again.

There, adhering to the plate was a perfect image of the scale on the celluloid ruler. Every line and inch number stood out as tiny ridges of powder. Small, but nonetheless real, electrostatic forces were holding the powder to the plate.

From this simple experiment was born xerography which, during some 10 years of research and development, was used mainly in the manual preparation of duplicate copies and offset paper masters and, in a few large machines, for high-volume copies. Now this fundamental concept has been embodied in a highly automatic desk-size office copying machine, introduced by Haloid Xerox Inc. under the name of Xerox-914 office copier.

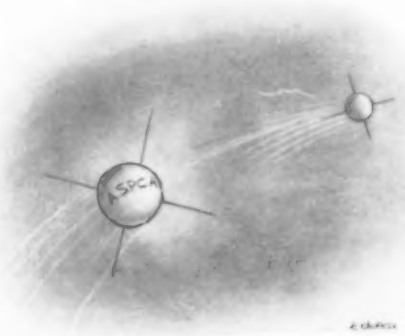
The process used in the 914 involves projecting the image of the original material onto an electrostatically charged selenium drum. Following exposure, a pattern of charged and discharged areas corresponding to the original image remains on the drum. Oppositely charged ink powder then is drawn to the charged areas and, in turn, is transferred to paper brought in contact with the drum.

Electrostatic competition

Also using an electrostatic process is the Electro-Stat desk-top copier recently put on the market by Apeco. The Electro-Stat, smaller in size than the 914, also differs in that the image of the original is projected directly to a sensitized sheet of paper, rather than a selenium drum. Both machines provide high-fidelity copies on low-cost papers.

A third electrostatic copier is reported under development by Charles Bruning Co. Inc., which expects to have its machine on the market soon. Other companies in the field also have announced developmental machines.

Some see in the electrostatic process the knell of carbon typewriter copies. Since the last copy from these new machines is as good as the first, it is more efficient, these observers say, simply to type an original and let the copy machine duplicate it in whatever volume may be needed. Thus, the often messy and time-consuming chore of correcting carbon copies can be eliminated.



Long-distance copying

Still another copying process, now in use to a limited extent, is photoelectric scanning, popularly known as facsimile. Considered primarily as a long-distance communications device at present, facsimile is developing rapidly in value as a copier for both interoffice and intraoffice use.

In photoelectric scanning, the original material is wrapped around a rotating drum and a blank copy sheet is wrapped around a second drum which rotates in synchronization with the first. (Some machines now can be fed material in flat form and, therefore, can take originals of any length.)

A narrow beam of light moves over and "reads" the original material. The light beam is reflected into a photoelectric cell where it generates a current corresponding in strength to the strength of the reflected light (which depends upon whether it is being reflected from a light or dark area). This current produces a corresponding current in a stylus of the second machine and the stylus, passing over the special copypaper, reproduces the pattern which has been "read" by the light beam on the original.

Quality of copies obtained by this method permits copying and transmission of material requiring very clear reproduction such as bank-account signatures. Facsimile also has been found useful in producing from a single order copy all necessary vouchers, invoices, shipping labels, etc., at the point of use. It also can take coded information from documents for punched-card or magnetic storage.

In long-distance transmission, facsimile is in use for sending large-size copy such as drawings or blueprints and for selectively transmitting vital portions of business documents.

Even more extensive long-distance use of facsimile may be forecast from an experiment in using the method to transmit mail from Washington, D.C., to Chicago, which was conducted from Oct. 17 to Dec. 2, 1960. If this service is adopted by the U.S. Postoffice Dept., it probably will work this way:

- The sender will write his letter on special paper, seal it, and drop it in the mailbox. When collected and taken to the postoffice, the sealed letter will be fed into a machine which, in seconds, will open it, transmit the message to the destination city, then destroy the original. (A computer will be used to control routing.) At the destination city, a postoffice receiving machine will produce and seal a copy of the letter, ready for delivery. Mail handlers will not see the message in either the sending or receiving city.

Disappearing confidential messages

A recent facsimile development is a recording paper from which the message temporarily disappears immediately after recording, then reappears later at a given time, a boon to both military and business operations of a confidential nature.

New also are increases in transmission speeds, which now are 10 to 15 times faster than previously have been possible with facsimile.

Companies with an eye on the future are experimenting further with facsimile. Now a copy can be made only in one office at a time; if intended for someone at a distant point, it has to be mailed. Copy-

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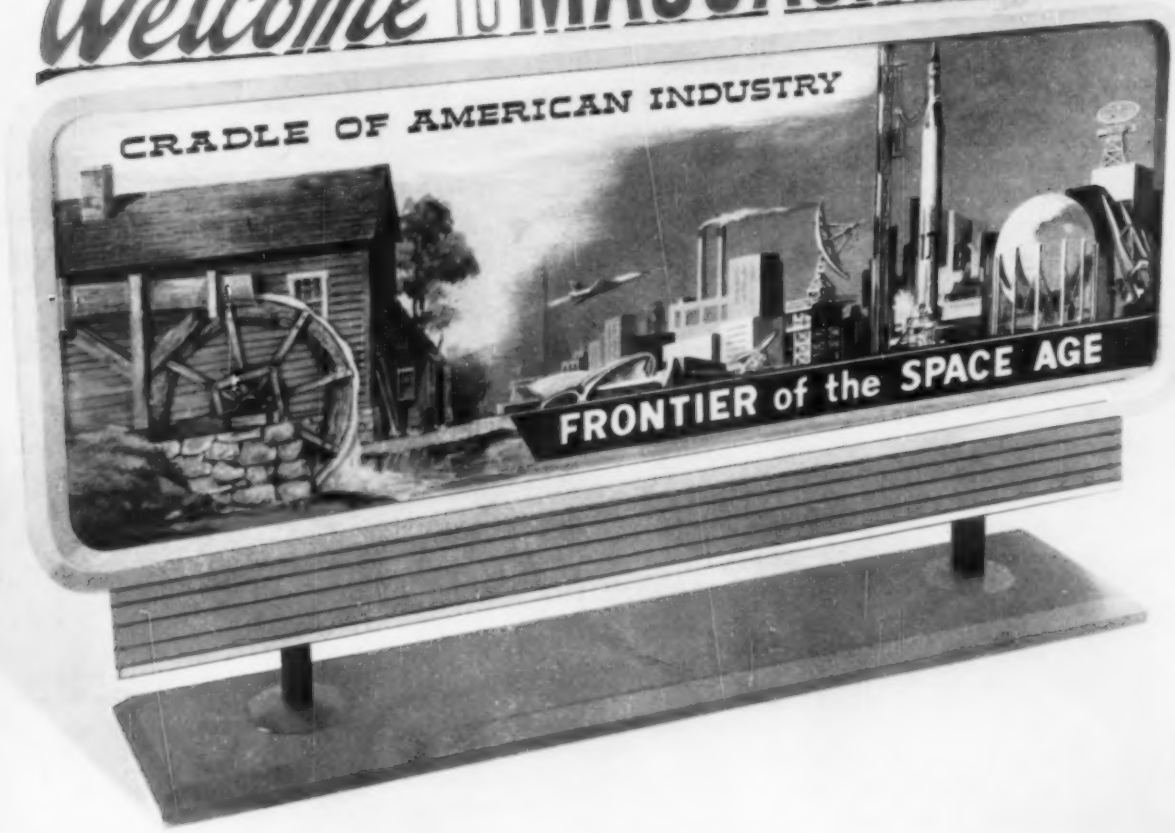

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machine manufacturers envisage office copiers that will transmit facsimiles to several points simultaneously.

Transmission will be by telephone lines, coaxial cables, or radio waves. And the transmitting office will have nothing more to do than dial the locations and send the copied message.

Which machine?

With the large variety of processes and models to select from, and with research developments making the future ever brighter for extensive use of office copying machines, businessmen today may have some questions about which particular kind of copier their offices should have.

The answer, quite sensibly, is that they should select the machine related best to their particular needs and budgets.

Some characteristics of the six basic copying processes are summarized in the chart on page 70. It perhaps should be pointed out that some models of all of these processes will prepare offset masters, a need in many offices. In addition, both electrostatic and facsimile methods can be used in making masters for spirit duplicators, and facsimile machines can be adapted for preparation of mimeograph stencils.

In some cases, special adapters are needed on machines to copy pages from bound volumes, but all the processes basically are capable of copying two-sided material (except diazo, which is the least expensive method, overall, but which requires original copy to be both one-sided and translucent).

While three of the processes—diazo, diffusion, and dye—involve use of liquids or vapors, early objections to this are being overcome, in the newest models, by engineering away the need for operators to handle the chemicals except in closed containers.

Tomorrow's copier

Today's crop of office copiers, for all their versatility, do not yet challenge the printing presses or duplicators, where runs of 6,000 an hour are common. However, if technological improvement continues at its present rate, copying speeds several times those of today's office copiers can be expected in the next few years.

Other attributes that probably will be required of them are simplicity of operation, ease of installation anywhere, and a minimum of attention and supplies. Basic requirements of such copiers must be low operating cost and suitability for large use. ■

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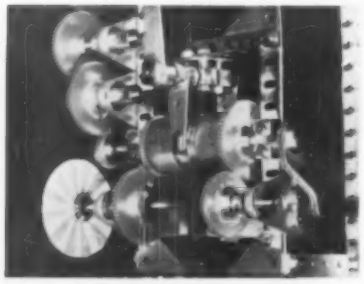

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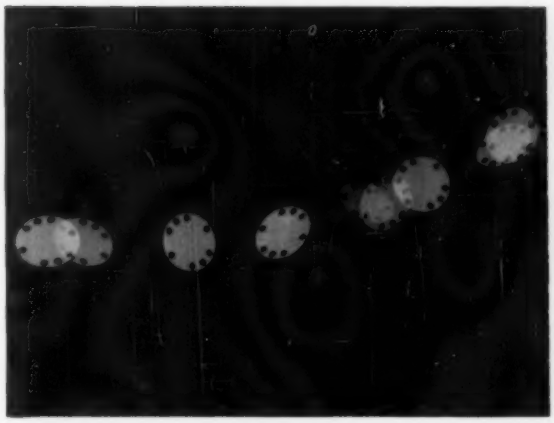

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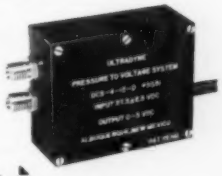

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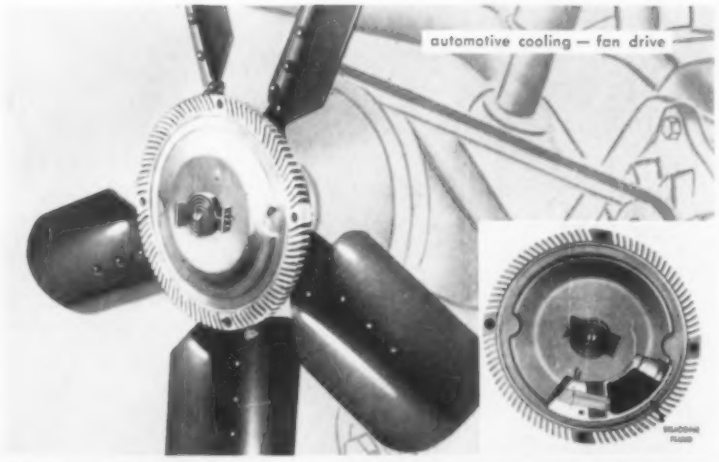

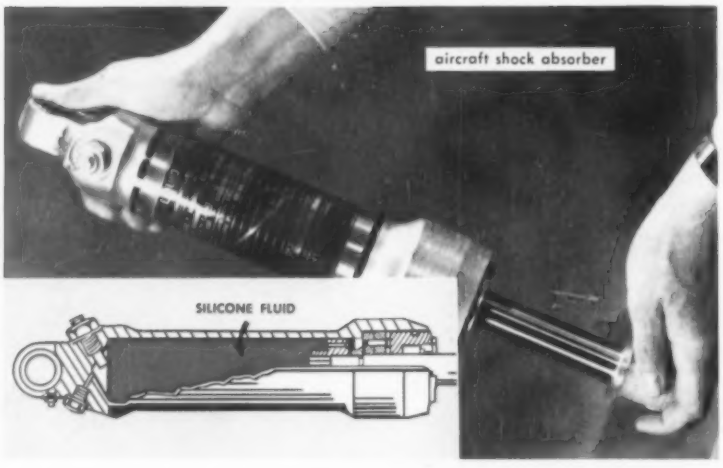

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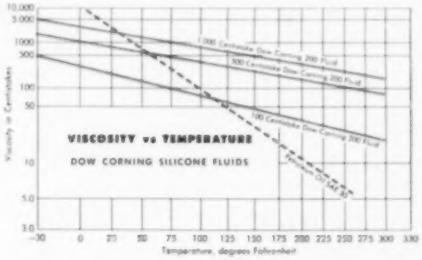

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